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(54) AN OBJECT MONITORING SYSTEM

GEGENSTANDS-ÜBERWACHUNGSSYSTEM

SYSTEME DE SURVEILLANCE D'UN OBJET

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- **Derwent Abstract Accession No. 86-168438/26, Class T07; & SU,A,1193716 (PROMAVTOMATIKA) 23 November 1985 (23.11.85), Abstract.**
- **PATENT ABSTRACTS OF JAPAN, P-1190, page 97; & JP,A,03 022 099 (MATSUSHITA ELECTRIC IND CO LTD) 30 January 1991 (30.01.91), Abstract.**
- **PATENT ABSTRACTS OF JAPAN, P-888, page 135; & JP,A,01 061 899 (MITSUBISHI ELECTRIC CORP) 8 March 1989 (08.03.89), Abstract.**

Remarks:
The file contains technical information submitted after the application was filed and not included in this specification

Description

[0001] The present invention relates to an object monitoring system and, in particular, to a system for monitoring vehicles.

[0002] Authorities responsible for traffic management and the laws which govern the use of vehicles require systems which can monitor traffic continuously and detect breaches of the law, without requiring the expense of having personnel present at the scene of the infringement. Systems which are able to monitor a large number of locations, detect infringements and issue infringement notices are particularly advantageous as they relieve personnel, such as police, from the task of traffic management and allow them to pursue other tasks. By continuously monitoring a location the systems also act as a deterrent to infringers and may assist in reducing accidents which cause road fatalities and casualties. It would also be advantageous to be able to monitor road usage in order to make decisions on road damage caused by heavy vehicles.

[0003] A number of traffic management systems are presently in use, such as speed cameras and red light cameras for road traffic. The known systems employ cameras which are triggered when an infringement is detected. Optical sensors placed on the side of the road, pressure sensors placed underneath the road and radar signals reflected from vehicles are used to detect the presence of a vehicle and determine infringement. The sensors and radar signals are used to generate a trigger signal to activate a camera to take a picture of the vehicle which includes details from which the vehicle can be identified, such as a car licence plate. Use of road based sensors is disadvantageous as they require the road to be altered or excavated for installation or, when placed on the side of the road, can be easily detected and damaged. Also electrical cabling needs to be installed and connected between the sensors and the camera. The use of electromagnetic signals which are transmitted to and reflected from a vehicle, such as radar signals, to detect presence and infringement is also disadvantageous as these signals can be detected by detection units placed in a vehicle to alert the driver as to their presence.

[0004] It is advantageous therefore to provide a system which can detect vehicle presence and infringement without transmitting any electromagnetic signals or using road based sensors.

[0005] The cameras presently in use also use photographic film which has the disadvantage that it needs to be continually replaced at the location of the camera. Accordingly, a number of red light cameras in metropolitan areas do not always include film and do not continuously monitor the corresponding intersection.

[0006] Speed detection systems which use only cameras are described in a number of publications. The systems are able to monitor traffic flow and detect instantaneous speed infringements but the systems are relatively limited with respect to the information they can obtain on a vehicle whilst it is being monitored, and the systems are also unable to selectively acquire information on specified vehicle types.

[0007] The pictures or images acquired by the camera also normally need to be examined by personnel to extract the information to identify the vehicle and determine the person responsible for it, which is a time consuming process. If the image could be processed within a relatively short time of acquisition then it could be used as a basis for alerting authorities in the region to seek and hold the vehicle, for example, if the information identifies it as being stolen. Accordingly, it would be advantageous to provide a system which can process images in real time to obtain detailed information on a vehicle and issue alert information and infringement notices without requiring human intervention.

[0008] When travelling a long distance, vehicle users, in particular truck drivers, tend to transgress speed limits so as to shorten the time in travelling to the destination and during the journey their speed may vary from a range which is under the limit to one which exceeds the limit. The known systems for detecting speed infringement concentrate on detecting the instantaneous speed of a vehicle at a particular location and therefore depending on the location at which the detection unit is placed, it may not detect users who infringe sporadically over a long distance. Also truck and bus drivers who exceed a recommended time of travel by avoiding rest stops and inaccurately complete log books may not be detected. Hence, it would be advantageous to provide a system which can detect the average speed of a vehicle over a relatively long distance. It is also advantageous to provide a system which can monitor vehicles in more than one lane of a multi-lane carriageway.

[0009] GB-A-2 227 589 discloses a camera system for acquisition and adjustment of a static object triggered by means of a photocell detector unit placed at a given location detecting the presence of the object. The system does not monitor movement of an object, but merely detects its presence.

[0010]. EP-A-0 339 988 discloses a traffic monitoring apparatus having a transceiver assembly that emits beams of radiation that are reflected back to the transceiver assembly by reflectors located in a thoroughfare. Interruptions of the beams by a vehicle and the space in between them are used to determine the presence of a vehicle and sense the speed of it. If a speed violation occurs, a video camera is triggered to acquire an image of the field of view of the camera which hopefully will include the vehicle.

[0011] The invention is achieved as set out in the appended claims.

[0012] According to the present invention there is provided an object monitoring system comprising camera means, characterised in that the camera means is adapted to monitor movement of an object to predetermine, based on the

monitored movement of the object, an acquisition time at which an image can be acquired at a predetermined position of said object relative to said camera means, and to acquire an image at the predetermined acquisition time and the predetermined position.

[0013] The present invention also provides an object monitoring system comprising camera means for monitoring moving objects, and image processing means, responsive to said camera means, for detecting a predetermined moving object from other moving and static objects.

[0014] The present invention further provides an object monitoring system comprising camera means for tracking and acquiring an image of a moving object from which information identifying said object can be automatically extracted.

[0015] Preferably said system includes means for transmitting said image over a digital telecommunications network.

[0016] The present invention also provides a vehicle monitoring system, comprising camera means for continuously detecting and tracking moving vehicles over a multi-lane carriageway, and acquiring images of predetermined vehicles at an acquisition area on said carriageway from which identifying information on said vehicles can be extracted.

[0017] The present invention also provides a vehicle monitoring system comprising camera means for monitoring moving vehicles to determine if said vehicle is of a predetermined type and, in response thereto, capturing respective images of vehicles of said predetermined type.

[0018] The present invention further provides a vehicle monitoring system comprising camera means for monitoring a vehicle to detect a law infringement and determine a predetermined time to acquire an image of said vehicle, and for capturing an image of said vehicle at said predetermined time in response to detecting said infringement.

[0019] The present invention also provides a vehicle monitoring system comprising camera means for monitoring vehicles on a roadway, discriminating between large vehicles, such as trucks and buses, and small vehicles, such as cars, on said roadway so as to acquire images of only the large vehicles from which vehicle information can be obtained.

[0020] A preferred embodiment of the present invention is hereinafter described, by way of example only, with reference to the accompanying drawings wherein:

Figures 1 to 3 are side views illustrating use of a preferred system for monitoring vehicles;
Figure 4 is a front perspective view illustrating use of a preferred system for monitoring vehicles;
Figure 5 is a block diagram of a preferred embodiment of the vehicle monitoring system;
Figure 6 is a block diagram of connection across a digital telecommunications network of two nodes and a central server of the vehicle monitoring system;
Figure 7 is a view illustrating connection of a large number of nodes of the vehicle monitoring system;
Figure 8 is a block diagram of vehicle detection and image capture circuitry of the vehicle monitoring system;
Figure 9 is a digitised image produced by the vehicle detection circuitry from an image generated by a detection camera of the system;
Figure 10 is a block diagram of the control of the circuit boards of the vehicle detection circuitry to perform a segmentation process;
Figure 11 is a static background image stored in the vehicle detection circuitry;
Figure 12 is a difference image generated by the vehicle detection circuitry;
Figure 13 is an image illustrating regions of shadow which are filtered from the image obtained by the detection camera;
Figure 14 is a segmented image derived by the vehicle detection circuitry;
Figure 15 is a histogram of pixel grey levels;
Figure 16 is a real time status display generated by the system;
Figure 17 is a flow diagram illustrating flow between the software tasks of the system;
Figure 18 is a diagram of the formation of "black triangles" in a processing window of the system;
Figure 19 is a diagram illustrating measurement of coverage of blob regions produced by the system;
Figure 20 is a diagram illustrating vertical extension of blob regions to perform clusters;
Figure 21 is a graph of extension amounts which are stored in a look-up table of the system;
Figure 22 is a diagram illustrating extension based on blob region width;
Figure 23 is a diagram of overlap detection for clusters produced by the system;
Figure 24 is a diagram illustrating a labelling method performed by the system;
Figure 25 is a diagram of the roadway coordinates used by the system;
Figure 26 is a graph of the trajectory of clusters;
Figure 27 is a graph of the trajectory of clusters transformed to the roadway coordinates;
Figure 28 is a diagram of data values obtained by trajectory software of the system;
Figure 29 is a block diagram of a timing control board of the system;
Figure 30 is a graph of the operating characteristics of the acquisition camera and infrared flash of the vehicle monitoring system;
Figures 31 and 32 are images acquired by the system;

Figure 33 is a block diagram of components of the acquisition camera, and interface components for the camera of the image capture circuitry;

Figure 34 is a block diagram of communications components of nodes of the system, and the components of an acquisition image processing system of the system connected over the digital telecommunications network;

Figure 35 is a diagram of the memory layout for a buffer board of the image capture circuitry;

Figure 36 is a flow diagram illustrating software modules of the acquisition image processing system and communications modules of the nodes;

Figure 37 is a block diagram of a licence plate recognition system of the vehicle monitoring system;

Figure 38 is a flow diagram of an image acquisition procedure of the licence plate recognition system;

Figure 39 is a flow diagram of the software modules of the licence plate recognition system;

Figure 40 is a flow diagram of a locate plate module of the licence plate recognition system; and

Figure 41 is a flow diagram of an optical character recognition module of the licence plate recognition system.

[0021] A vehicle monitoring system, as shown in Figures 1 to 7, includes a camera node 2 which is mounted on a bridge or pylon 4 above vehicle traffic, as shown in Figures 1 to 3. The camera node 2 includes a vehicle detection camera 6, an image acquisition camera 8 and a node control unit 10. Both cameras 6 and 8 are monochrome CCD cameras, with the vehicle detection camera 6 being a wide angle video camera of medium resolution, and the image acquisition camera being a high resolution camera.

[0022] The detection camera 6 has a wide field of view 12 of part of a vehicle carriageway 16 which is to be monitored by the node 2. The detection camera 6 monitors vehicles in the field of view 12 and the control unit 10 processes the images acquired by the detection camera 10 to detect and discriminate vehicles from other objects in the field of view 12. As a vehicle 18 enters the field of view 12 and moves towards the node 2, the node 2 analyses the images produced by the detection camera 6 to first detect the vehicle 18 as being a moving object, which is different from other moving objects or the still background in the view 12, and determines whether the vehicle 18 constitutes an object for which a high resolution image thereof should be obtained by the image acquisition camera 8. The image acquisition camera 8 is mounted on the bridge or pylon 4 so as to have a limited field of view 20 which will include the front of a vehicle 18 when it reaches a predetermined location 22 on a carriageway 16. The location 22 and the field of view 20 are chosen to be near the point where moving vehicles will leave the field of view 12 of the detection camera 6, as shown in Figure 3. On determining that the vehicle 18 represents an object for which an image is to be acquired, the node 2 estimates the time when the vehicle 8 will enter the field of view 20 of the acquisition camera 8, on the basis of the movement of the vehicle which has been monitored by the detection camera 6. The node 2 provides trigger information to control circuitry associated with the acquisition camera 8 so as to trigger the camera 8 at the estimated time. A high resolution image of the front of the vehicle 18 is obtained from which considerable identifying information can be derived, such as vehicle type and licence plate details, by subsequent digital electronic processing of the image.

[0023] In addition to identifying the vehicle 18 and estimating the time for triggering the acquisition camera 8 the node 2 is able to use the images from the detection camera 6 to discriminate between vehicles on a number of characteristics, such as size, to determine those for which high resolution images are to be acquired. For example, the system is able to distinguish between large vehicles such as trucks and coaches, and other moving objects within the field of view 12, such as cars and motor bicycles. The node 2 is also able to determine from the images obtained by the detection camera 6 the current speed of the vehicle 18 and whether the driver is committing any traffic or other offences, such as tailgating or illegal lane changing. The system can also be used to detect stolen vehicles.

[0024] The detection camera 6 and the control unit 10 are able to monitor all of the moving vehicles 18 and 22 within the field of view 12 whilst acquiring the images of selected vehicles at the location 22. For a multi-lane carriageway 21, as shown in Figure 4, the field of view 12 of the detection camera 6 extends over all of the lanes 23 and 25 of the carriageway and an image acquisition camera 8 is provided for each lane 23 and 25. The node 2 is therefore able to monitor the moving vehicle 18 to determine in which lane it will be when it reaches the image capture location 22 and activates, as required, the acquisition camera 8 corresponding to that lane 23 or 25.

[0025] The control unit 10, as shown in Figure 5, includes vehicle detection circuitry 30 for processing the images generated by the detection camera 6 so as to provide trigger signals on a bus 32 to the image acquisition camera 8. A selected camera 8 is triggered to acquire an image in accordance with the timing information determined by the detection circuitry 30, and the camera 8 provides a trigger signal on a line 36 to a flash triggering circuit 38, of a corresponding infrared flash 40 mounted adjacent the selected acquisition camera 8. The image obtained by the trigger acquisition camera 8 is received by an image acquisition circuit 34. The detection circuit 30 determines the light intensity within the field of view 12 of the detection camera 6 so as to determine the correct level of exposure for the acquisition camera 8, and in turn the correct level of energy to be discharged by the flash 40 to achieve the desired level of exposure. The use of an IR flash is advantageous as activation is difficult to detect visually. Visible wavelengths produced by the flash are removed by IR band pass filters.

[0026] The vehicle monitoring system includes an acquisition image processing system 42 connected to the control

unit 10 for receiving and processing the images acquired by the camera 8 to extract vehicle information therefrom. The acquisition image processing system 42 may form part of the node 2 or be positioned remote from the node and connected to the control unit by a telecommunications line 44 from the acquisition circuit 34. The system 42 comprises a processing station 43 configured to automatically extract the required information from the image, such as licence plate details 50.

[0027] The acquisition image processing system 42 when implemented at a remote central site, as shown in Figure 6, includes communications controllers 55 connected to a public digital telecommunications network 45, and a central computer server 47 which serves a local area network (LAN) connecting computers which implement an acquisition image database 49, a licence plate recognition system 51 and a remote site user interface 53. The communications controllers 55 are provided for each node 2 which sends images to the processing system 42. The nodes 2 each include an image buffer and communications controller 57 for storing images obtained by the acquisition circuit and communicating with the communications controllers 55 of the central image processing system 42 to send the images over the integrated services digital network (ISDN) 45 to the central server 47. The communications controllers 55 manage the high speed image transfers over the ISDN 45, and handle housekeeping, error detection and correction for image transfers between the nodes 2 and the central server 47. The central server 47 communicates with the controllers 55 so the nodes 2 act as extensions of the LAN maintained by the server 47. Image processing can also be performed at each of the nodes 2, for example, the nodes 2 may each include a licence plate recognition system 51 which performs optical character recognition (OCR) on the acquired images to extract vehicle information, such as licence plate details.

[0028] The vehicle monitoring system, as shown in Figure 7, comprises a plurality of camera nodes 2 mounted at a number of locations 52 to 60 on vehicle carriageways. The nodes 2 may be connected by telecommunications lines of the ISDN 45 to communicate with another and/or connected to a central control station 62, so as to compare information collected at each of the nodes 2. The control station 62 includes the acquisition image processing system 42. The nodes 2 and the control station 62 are able to monitor a vehicle's progress along the carriageways 16, 64 using information collected by the nodes 2, which includes, in addition to vehicle identifying information, the date, time and location at which an image is acquired. This is particularly advantageous as the information can be used to determine the average speed at which a vehicle has travelled between two nodes 2. If the average speed indicates that the vehicle has exceeded the speed limit in travelling between the nodes, then authorities can be contacted so as to intercept the vehicle. Alternatively, the central station 62 issues an infringement notice to the registered owner of the vehicle. The station 62 and/or the nodes 2 may also contain information on stolen vehicles and the authorities are contacted when a stolen vehicle is detected. Vehicle drivers negotiating long distances would be reluctant to instantaneously exceed the speed limit at chosen locations, if they are aware that they will be intercepted or issued with an infringement notice by travelling between two locations 52 and 54 of two nodes, too quickly. The distance between the nodes would be relatively large and an allowable time for travel between the nodes would be established corresponding to a permitted average speed. The ability to monitor average speeds by the system represents a significant development which can be used to deter excessive speeding by large vehicles, such as trucks and buses, on major roads, and further enables detection of drivers who fail to take scheduled rest stops.

[0029] The detection camera 6 produces video fields of 312 and 313 horizontal scan lines respectively which are each duplicated to produce a complete 625 line video frame. The fields are converted into 512 × 512 pixel 8 bit quantised digital images which occur at a video field period of 20 ms. The vertical resolution of the detection camera 6 is dependent on the vertical field line resolution which is approximately 300 elements, digitised into 512 pixels, for a maximum distance which the camera 6 can view on a horizontal roadway. The maximum distance D is given by:

$$D = h\tan\left[\arctan(D_{min}/h) + \Phi\right] \qquad (1)$$

where

- D = distance along road covered by camera view
- h = height of camera above road
- D_{min} = distance of closest position of camera view along roadway
- Φ = lens field of view angle

The field of view across the roadway is given by:

$$W = \left(\frac{w}{f}\right)L \qquad (2)$$

where

W = field of view across the roadway
w = width of the sensor
f = lens focal length
L = object distance from camera

[0030] The camera 6 includes a 12 mm lens and an 8.8 mm × 6.5 mm CCD sensor to optimise vehicle image size and maintain a four lane coverage, 3.5 metres per lane, at the image acquisition points 22. An antiblooming and antismear sensor is included to prevent blooming or smearing of an image by vehicle lights. The infrared filter of the camera permits a infrared wavelengths up to 950 nm, which allows the detection camera 6 to receive the infrared component of vehicle lights, thereby providing more image information to detect and monitor vehicles. The detection camera 6 has a +40 dB gain range, and the exposure time is fixed at the field period, 20 ms.

[0031] The exposure control of the detection camera 6 controls the intensity of light falling on the camera sensor so as to maintain consistent video signal quality and obtain a predictable representation of a vehicle. Acceptable exposure of the sensor can be maintained through the appropriate match of sensor sensitivity and control of the intensity or power of the electromagnetic wavelength falling on the sensor, as shown with reference to equation 3.

$$E \alpha (HA)T \qquad (3)$$

where

E = exposure of light on sensor
H = incident e.m.r. power per cm^2 (irradiance)
A = area of pixel site in cm^2
T = time in seconds that light or e.m.r. falls on sensor

[0032] The time T light falls on the trigger camera is held constant at the video field rate of 20 ms. This is sufficiently short to "freeze" the motion of the vehicle in the relatively large field of view 12 of a multi-lane carriageway. A shutter is not included in the detection camera 6 as electronic shutters or short duration exposure control produced adverse effects from either image smear or blooming from sunlight reflections or vehicle headlights, as exposure times were shortened. The incident light irradiance, H, required to provide sufficient exposure of a sensor pixel is dependent on the sensitivity to a particular wavelength of light. Sensor pixels also have a minimum light sensitivity to produce a satisfactory signal to noise ratio in the video signal, and a maximum light level before the sensor pixels become saturated. The range of light irradiance that can be imaged in a single exposure for the sensor is approximately 100:1. The range of light irradiance which can be presented to the camera 6 during a 24 hour period can be varied by as much as 10^5:1. Accordingly, the exposure control system limits H sufficiently to maintain it within the dynamic range of the sensor to prevent sensor saturation from the illumination levels typically present during a 24 hour period. The exposure control is a f1.8 to f1000 auto iris lens system which is designed to provide exposure adjustment based on lens aperture and progressive neutral density filtering of light as the lens aperture decreases. The rate of change of the exposure control, or the rate that H changes, is restricted as moving vehicles are located by differencing images obtained by the camera 6 from a slowly changing background image, as described hereinafter. The rate of change is restricted to ensure changes in exposure of the sensor are not mistaken for changes in the background image, which would adversely affect detection and monitoring of vehicles. The auto iris reaction time is set to match the ratio at which background images are subtracted from the current image. The slow rate of change also prevents the iris responding too fast to transient changes in light, for example, reflected off roofs of vehicles as they pass close to the camera 6. The rate of change is restricted to 10 seconds for a halving or doubling of light irradiance H.

[0033] The exposure control system ensures that transient extremely bright reflections or headlights do not saturate the sensor pixels by limiting the exposure on the sensor to keep it below the sensor's saturation level for the peak intensity of light received in the field of view 12. The peak video level obtained from the camera 6 is monitored, as discussed hereinafter, and used as a basis for controlling the setting of the diaphragm of the iris.

[0034] The sensor sensitivity is selected in order to produce video signals which allow the subtraction of the back-

ground for vehicles not using headlights during dusk and dawn illumination levels. The sensor is also responsive to near infra-red light to maximise the signal from large vehicle side and perimeter lights, yet the response must be still below a threshold where blooming may occur from vehicle headlights. The lens of the camera 6 can be controlled fully to provide sufficient exposure for the sensor for vehicles without headlights during the dawn and dusk periods. The maximum lens aperture is held at f4 for a luminance value of about 10 cd/m^2 reflecting from the carriageway. Once the carriageway luminance level fall below approximately 25% of this level, vehicle segmentation, as discussed hereinafter, is based on vehicle headlights. Control signals representative of the illumination levels are derived from an illumination histogram of video signal levels for the pixels, described hereinafter.

[0035] The control unit 10 of a camera node 2, as shown in Figure 8, includes a Motorola 68030 CPU 64 and a detection and trigger sub-system 66 connected to receive images from the detection camera 6, and an acquisition sub-system 68 connected to receive images from the acquisition camera 8. The sub-systems 66 and 68 include a number of Datacube pipelined pixel rate video processing circuit boards which are controlled by the CPU 64. The boards and the CPU 64 are mounted on and interlinked by a VME (Versa Module Europe) bus. The CPU 64 and the boards of the sub-systems 66 and 68 run a software operating system known as VxWorks, which is a real time multi-tasking system. The detection sub-system 66, the CPU 64 and controlling software form the detection circuit 30, and the acquisition sub-system 68, the CPU 64 and the controlling software form the acquisition circuit 34. The image buffer and communications controller 57 can be connected to the acquisition circuit to provide access to the ISDN 45.

[0036] The detection sub-system 66 processes the 512 × 512 pixel images of each video field obtained by the detection camera 6 and is designed to achieve low latency between changes in the field of view 12, by using pipelined processing of the image data with no intermediate storage. The data rate through the video data paths of the pipeline, known as MAXBUS, is 10 million pixels per second. Processing the video fields individually, as two consecutive frames of half vertical resolution, achieves a sample rate of 50 Hz and eliminates the deinterlacing latency required for full frame processing.

[0037] The detection sub-system 66 includes a video digitiser board 74 which receives the fields output via the detection camera 6 and converts them into the 512 × 512 pixel representation. The digitiser board 74 is a Datacube Digimax board and produces a greyscale image representation with each pixel having a value within the 2's complement positive range of 0 to 127, 0 representing black and 127 representing white. The 512 × 512 pixels are able to produce a live image display as shown in Figure 9. The image produced by the digitiser board 74 is input to a background differencer board 76 which, as shown in Figure 10, subtracts a background image, as shown in Figure 11, from the current or live image to produce a preliminary difference image, shown in Figure 12. The difference image comprises a grey level of representation of the moving objects within the field of view 12. By virtue of the image subtraction the pixel image range for the difference image extends from -128 to 127. The background differencer board 76 is a Datacube MaxSP board.

[0038] The background image represents the static background viewed by the detection camera 6 and is stored in one of two framestores 71 of a background image store board 70, being a Datacube Framestore board. The background image is continually updated by a background update board 72, which is another Datacube MaxSP board that ensures one of the framestores 71 holds an image correctly representative of the static background within the field of view 12 of the detection camera 6. The update board 72 then receives the current background image from one of the framestores 71b and is combined with a filtered form of the preliminary difference image to produce a new background image which is outputted by the update board 72 to the other framestore 71a. The controlling software then switches to the other framestore 71a for submission of the background image to the differencer board 76, and ensures the next updated image is submitted to the first framestore 71b. The background update board filters the preliminary difference image in accordance with a filter characteristic 73, as shown in Figure 10, which is held in RAM and performs a limiting function on the grey level pixels of the preliminary difference image so as to restrict them between a programmable range, for example -2 and +2 pixel range. The limiting function restricts the correction made to the current background image when it is combined with the difference image, after having been subject to a delay 74 to allow for the time taken to apply the limiting filter function 73. The limiting function ensures the correction made to the background image per frame is only slight so that transient differences, such as those produced by moving objects, are not allowed to significantly alter the stored background image held in the image store board 70. The shape of the filter function 73 represents that grey level differences added to the background image are confined to a level t for all difference levels >t and -t for all difference levels <-t, where t is a low threshold such as 2. The state of the background update board 72 can also be changed to disable update of the background image. The rate of change in the background image is set so as to be faster than the rate of change of scenic exposure due to variation in the lens aperture of the detection camera 6. The rate change governed by the limiting function is important because if the rate is too slow lighting changes can produce incorrect difference images, and if the rate is too fast then moving objects may appear in the background image as a blur.

[0039] The preliminary difference image produced by the background differencer board 76 is outputted to a third Datacube MaxSP board, a shadow elimination board 77. The shadows produced by vehicles which appear in the

difference image, shown in Figure 12, pose a significant problem for the images processed to determined the type of vehicle. The shadows can mistakenly represent the vehicle as being larger than its actual size, and if a discrimination is being made between the large vehicles, such as trucks and buses, and small vehicles, such as cars and motorcycles, then the shadow cast by a car can lead to it being classified as a large vehicle. Therefore the shadow elimination board 77 is employed to eliminate all grey levels in the difference image which could represent shadows. This is done by defining a grey level window range 79 in RAM, as shown in Figure 10, whereby the preliminary difference image is processed so as to set to zero all pixels having a grey level within the window 79. The result is then used to mask the preliminary difference image so that the elimination board 77 outputs a shadow filtered difference image having all of the pixels with grey levels within the window range 79 removed. Figure 13 illustrates a live image with all of the pixels having a grey level within the range of the window 79 shown as green. The range defined by the window 79 is adjusted depending on the light conditions within the field of view 12 of the detection camera 6, as discussed hereinafter.

[0040] The shadow filtered difference image is inputted to a threshold and median filter board 78, which is a Datacube Snap board. The filter board 78 performs binary image processing on the difference image so as to convert the grey level representation of the moving objects to a binary representation, which corresponds to white or black, for further processing by the detection sub-system 66. The filter board 78 uses a threshold value to convert all of the pixels, with grey level values within the range -128 to +127, to pixels having values of either 0 or 255. Accordingly, the final difference image produced by the filter board 78, when viewed by a real time display, shows the moving objects within the field of view 12 as a collection of white pixel blobs, as illustrated in Figure 14. The blobs may correspond to parts of moving vehicles which reflect sunlight and, at night, may correspond to light produced by a vehicle's external lights. Noise regions of one or more pixels in size are eliminated by the board 78 which performs binary median filtering on 3 by 3 pixel neighbours.

[0041] The light conditions within the field of view 12 of the detection camera 6 are determined with reference to a histogram 150, as shown in Figure 15, of pixel grey levels produced by the CPU 64. The CPU 64 processes a window of the stored background image which is approximately 300 x 400 pixels every 10 seconds. The CPU 64 calculates the number of pixels in the window having each grey level and tabulates the results as the histogram 150, with the number of pixels on the vertical axis 152 and the grey level values on the horizontal axis 154. The histogram 150 can be displayed to provide a real time representation of the light within the field of view 12. From the grey level value which represents the position of the median 156, one of three lighting conditions, day, dusk, or night, can be instantaneously determined. Dawn is considered to be the same lighting condition as dusk. The positions of the peak 155, median 156 and the minimum 158 are used to determine the range of the window 79 used in the shadow elimination board 77. For daytime conditions, the shadow window 79 is determined as being from the values α.peak to (peak + median)/2, where α is typically 0.5. For dusk conditions, the shadow window 79 is from minimum to (peak + median) /2. Shadow pixels of course, do not need to be eliminated during night conditions. Estimation of the shadow pixel range is an approximate technique which is aided if areas of permanent shadow are in the field of view 12, such as cast by trees or an overpass bridge.

[0042] The segmented images produced by the filter board 78 are submitted to an Area Perimeter Accelerator (APA) board 80, which is an APA 512 board produced by Atlantek Microsystems, of Adelaide Australia, designed to accelerate the processing of area parameters of objects in a video scene. The board 80 operates with controlling software to perform analysis of the white pixel blobs within a 300 × 400 pixel window corresponding to the window on which the histogram 150 is produced. The APA board 80 and the software perform a classification and feature extraction process in real time on the blobs so as to facilitate the formation of clusters of blobs which correspond to a moving vehicle. The APA board 80 computes features of the white pixel blobs and the features are used by the clustering software to determine, on the basis of rules and classification code, whether the blobs can be combined to form a cluster. Once formed, the size of a cluster indicates whether it corresponds to a large vehicle, such as a truck or bus, or a small vehicle, such as a car. Labelling software is used to monitor movement of clusters over successive fields so as to determine which clusters are to be assigned a unique label and which clusters are to share a label, as they are considered to relate to the same vehicle.

[0043] Different considerations apply in respect to whether the carriageway 16 is being viewed by the detection camera 6 at night or during the day, and the rules and classifications used are adjusted, on the basis of the data provided by the histogram 150, to account for night conditions, rain and inclement weather, which result in a moving vehicle producing different corresponding pixel blobs. For example, the rules and classification code needs to be adjusted to account for reflection produced by vehicle lights on the road during night conditions.

[0044] Once a cluster has been formed, its movement is monitored to determine its instantaneous speed and its position with respect to a point on the edge of the road using Kalman filter techniques. Corrections are made for perspective as the cluster moves towards the cameras 6 and 8. The information obtained from monitoring the movement of the cluster is used by the CPU 64 to predict when the cluster will enter the field of view 20 of the acquisition camera 8, and in particular when a vehicle reaches a position 22 which an image of the vehicle is to acquired. The predicted time estimate is updated for every field generated by the detection camera 6, 50 times per second. The predicted time

is continually corrected as the CPU 64 monitors movement of a cluster until it is satisfied the cluster will enter the field of view within 10 to 20 ms. A CPU 64 predicts the time by specifying the number of scan lines which need to be scanned by the camera 6 before the clusters within the field of view 20.

[0045] Performance of the control unit 10 can be monitored and controlled by peripheral devices, such as a printer 94 for error and event logging, a real time status display 98, and a control workstation 100, which may all be connected to the CPU 64 and the boards of the control unit 10 directly or by a local area network 102. A display of the real time status display 98 is illustrated in Figure 16 which is the live image produced by the digitiser board 74 superimposed with cluster markings and other data. The histogram 150 is displayed at the left of the screen and the box around the vehicles are clusters which have been formed. The label number for each cluster is shown at the lower right hand corner of each cluster, and the estimated speed of the vehicle, obtained by monitoring the cluster, is displayed directly below the label number. The large box around the vehicles represents the processing window, on which the clustering, labelling and tracking software operate, in addition to the histogram software. The line across the window is an acquisition line which corresponds to the position 22 at which high resolution images are to be acquired by the acquisition camera 8. A diagnostic graphics board 82, which is a Datacube Maxgraph board, is used to queue and configure graphic images for the real time status display 98.

[0046] The image processing performed by the CPU 64 and the APA board 80 for vehicle classification is handled by feature extraction, clustering, labelling and tracking software. The operation of the software is largely controlled by parameter variables, which may be altered via an interactive shell of the software or by remote procedure calls from a graphical interactive command tool running under Xwindows on the control workstation 100.

[0047] The APA board 80 reduces the binary image pixels into a stream of feature vectors representing the blobs, or regions, in the images. Only a small sub-set of the features which can be computed by the APA are required, being the area, perimeter and bounding box for each blob, or region. A region is represented by raw data of 16 bytes and for a field of view 12 which includes 20 regions, the data rate is 16 kbytes/s which is less then 0.2% of the data rate for binary images, and is reasonable for software processing by the CPU 64.

[0048] The raw seed parameters are read from the APA hardware by the APATask 170, as shown in Figure 17. A time stamp is given to each blob, and some initial screening is performed, where regions such as "black triangles" described hereinafter, are located and removed. Time stamping, inter alia, allows any latency in the system to be measured and compensated for. The seeds which correspond to white blobs within certain area constraints are passed via a VxWorks message pipe to the seedTask 172. The seedTask unpacks the raw seed parameters, or structures, and performs classification of regions based on each regions height to width ratio, "circularity", area and "coverage", as described hereinafter. Unwanted regions such as headlight and road reflections are removed and then each classified region is passed via another message pipe to the clusterTask 174.

[0049] The clustering task is divided into five subsections 176, region classification, region extension, clustering, region unextension and cluster classification. Once the regions have been clustered into clusters which have been classified as corresponding to separate vehicles, the coordinates of the clusters are passed onto a label task 178, once again by a message pipe. The label task monitors each cluster over a given period of time and if a cluster appears in roughly the same place as did a cluster from a previous video frame, then the label task considers them to be the same cluster. In this case, the new cluster inherits the label from the previous cluster. Otherwise if no match can be made, the new cluster is given a new label. The cluster's coordinates, along with its label, is then passed via another message pipe to a trajectory task 180. The trajectory task 180 determines the time to trigger the acquisition camera 8 for clusters of a selected class, such as large vehicles. The put cluster box task 182, remove cluster box task 184, put label task 186, remove label task 188 and the histogram task 190 are tasks used to generate graphics overlaid on the video image, as shown in Figure 16, for diagnostic purposes.

[0050] The blob shape analysis performed by the APATask 170 and seedTask 172 is not extensive during daytime segmentation, as all blobs are considered valid. However, during dusk and night time segmentation, blobs can occur due to vehicle headlight reflection, and if these blobs are clustered in with true vehicle blobs, then the front-of-vehicle coordinates, which are taken from the bottom of the cluster box, will be incorrect. In order to correctly locate each cluster box at the front of each vehicle, blobs which are recognised as being due to headlight reflections are identified and removed before blobs are clustered. Other problem blobs are those which correspond to road lane markers. These appear when the mount for the detection camera 6 shakes. During camera shake, the incoming video image no longer precisely corresponds to the stored static background image, and therefore the result from the background image subtraction is that the road markers appear to have moved. Again, the blobs that result from camera shake are identified and filtered out before clustering commences. A further problem is "black triangles". The APA board 80 possesses a hardware fault which causes the polarity of blobs to be specified incorrectly. If a black region finishes at the right hand side of the pixel processing window, it can be inadvertently labelled as a white region by the APA board 80. These white regions can then become candidates for clustering unless filtered out by the seedTask 172. Typically, when a lane marker 190 appears on the right side of the pixel processing window 192, as shown in Figure 18, it produces a black triangular blob 194, a "black triangle", which is inadvertently represented by white pixels, in the top right hand

corner. The triangular blob 194 is identified and removed. A convenient side effect of the polarity fault is that the road lane line-marker 190, which usually must be identified and removed by other shape characteristics, is labelled by the APA board 80 as black, and is therefore automatically filtered out.

[0051] Regions are classified into one of the following types:

(i) Headlight reflections;

(ii) Road artefacts; such as road lane markers, which appear due to camera shake,

(iii) Lights; and

(iv) Other; during daytime segmentation most of the regions that are not classified as road artefacts are classified "other".

[0052] During day and dusk conditions, illuminated headlights do not appear segmented from other segmented parts of a moving vehicle, and so lights are not classified. At night, however, circular regions are classified as either "headlight" or "small-light", depending on the area and position within the field of view 12. Distant headlight pairs which are typically segmented from the background image as a single joined region, are classified as "joined headlights". To obtain correct initial clusters, distant joined headlights need to be distinguished from the small perimeter lights of large vehicles.

[0053] The main shape measure that is used during dusk and night time processing is "circularity". This is a measure which considers how close each blob is to the shape of the circle by comparing the blob's area to its perimeter. In the case of a circle:

$$\text{Area} = \pi r^2 \tag{4}$$

$$\text{Perimeter} = 2\pi r \tag{5}$$

[0054] The radius term can be eliminated, since it is only relevant for circles, by squaring the perimeter equation and taking the quotient of the two terms. For a circle, this produces a constant:

$$\frac{\text{Area}}{(\text{Perimeter})^2} = \frac{\pi r^2}{(2\pi r)^2} = \frac{1}{4\pi} \tag{6}$$

[0055] To make a circularity measurement equal to 1 for a circle, equation 6 is simply multiplied by the inverse of the constant. This provides a circularity measure which can be applied to blobs whereby a circular blob will have a measurement value of 1, as follows:

$$\text{Circularity} = \frac{4\pi\text{Area}}{(\text{Perimeter})^2} = 1.0 \tag{7}$$

[0056] For a square blob of unit area, Area = 1, Perimeter = 4, the circularity measures is as follows:

$$\text{Circularity} = \frac{4\pi \cdot 1}{(4)^2} = \frac{\pi}{4} \approx 0.785 \tag{8}$$

[0057] For an equilateral triangle with sides of unit length, Area = $\sqrt{3}/4$, Perimeter = 3, the circularity measures is as follows:

$$\text{Circularity} = 4\pi \cdot \frac{\sqrt{3}}{4} \cdot \frac{1}{(3)^2} = \frac{4\pi\sqrt{3}}{36} \approx 0.6 \tag{9}$$

[0058] A further measurement employed, that is particularly useful in detecting road land/line markings, is "coverage". Coverage is the measured ratio between the area of a blob to the area of its bounding box. The bounding box 200, as shown in Figure 19, is aligned with the APA board coordinate axes, which are the axes of the APA processing window.

The APA axes are not necessarily aligned with the major axis of the blob itself. For instance, a rectangular blob 202 which is aligned with the APA coordinate axes would have a high coverage value, whereas a rectangular blob 204 which is not aligned with the axes may have a medium coverage value. A concave shape 206 would produced a medium coverage value, and a line 208, diagonal to the APA coordinate axis 201 would produce a low coverage value. Road lane markings can be simply detected because they have a low coverage value. If the lane markings are not diagonal, but vertical, then the measure is insufficient and in such cases a measure of the ratio of the blob's major axis length to it's minor axis length can be used instead.

[0059] During night time segmentation the coagulated blobs of joined headlights are identified by their height to width ratio as they tend to be twice the expected area of one headlight. Joined headlights need to be detected so that a headlight count maintained for each cluster is correct.

[0060] Headlight reflections appear as large elongated blobs, and are detected initially on the basis of their size and characteristic shape. The blobs are confirmed as relating to headlight reflections by extending the blobs vertically to determine whether they extend from a headlight region.

[0061] As the vehicle monitoring system is capable of continuous automatic operation, clustering of regions takes into account different lighting conditions. The technique of static background subtraction, described previously, segments moving objects from the video image obtained by the detection camera 6, but the regions that result from the segmentation process depend on the ambient lighting conditions at the time of day. During daytime segmentation, large regions typically result, whereas during night time only headlights and the smaller sidelights on trucks are segmented. During dusk, lit headlights do not appear segmented from the other visible parts of moving vehicles, however, reflections upon the surface of the road caused by the headlights need to be removed, as discussed above.

[0062] The clustering process operates on the segmented regions or blobs and each vehicle is typically segmented into several separate regions, as shown in Figure 12. For instance, a car will often appear split by its windscreen into a roof-region and a bonnet-region. Large vehicles typically segment into more regions. The cluster task groups these regions into "logical vehicles" so that they can be tracked. Distant vehicles tend to be segmented together into one region due to vehicle occlusion at the image horizon. While the segmented regions at this distance can be tracked, they cannot be reliably clustered into separate vehicles. Emphasis is placed on correctly clustering lower regions that are closer to the acquisition line 22, and consequently the clustering process scans from lower regions to higher regions in each image.

[0063] If two vehicles are segmented into the same region, then they will be clustered together. The cluster task does not separate vehicles that have been segmented together into a single region. The coordinates of each cluster are sent to the label task 178 which matches and separates clusters over consecutive video fields. The cluster task and the label task classify clusters on the basis of classification data. The coordinates passed to the trajectory task 180 correspond to an estimation as to the front of the vehicle, at the road surface level. Cluster information on all vehicles is provided to the trajectory task, which tracks the clusters and selects for which vehicles images are to be acquired.

[0064] Optimal clustering is achieved as a middle point between "over clustering" and "under clustering". At the over clustering extreme, all regions are clustered into one single cluster and then only the lowest vehicle in the cluster is tracked. This is because the lowest point of each cluster is passed by the label task to the trajectory task. The classification of the cluster, which is based on its height and width will be incorrect. At the under clustering extreme, if no regions are clustered together, that is each region obtains its own unique cluster and label, then the trajectory task is over-burdened in an attempt to track every region, vehicle classification will fail in a number of instances, and images will be inadvertently acquired and missed. For the purposes of vehicle image acquisition, it is better to mistake a vehicle-roof for a vehicle-front and begin to track it than it is to mistake a vehicle-front for vehicle-roof and so, by adding it to the back of another cluster, not track the vehicle-front. Therefore the cluster task has been written to use an optimal middle point which lies on the side of under clustering rather than over clustering.

[0065] The cluster task performs clustering essentially by extending the boundary of each segmented region by a certain amount, and then joining any regions that overlap. Regions that overlap are "clustered". The cluster task, however, determines correctly the amount of extension which should be applied to each region. During daytime segmentation, very little region extension is required, yet during night time, the segmentation process produces small sparse regions that require large amounts of extension in order to achieve overlap.

[0066] An important aspect in the construction of a cluster is that the bottom region of each cluster should be the front of a vehicle. Invalid regions, such as regions due to headlight reflections, must not be clustered, and are thus not extended. After every valid vehicle region in the image is extended by a certain amount, the clustering process begins with the lowest region in the image. The lowest is considered first which is the region most likely to cause triggering of the acquisition camera 8.

[0067] The coordinates of the lowest region are used to initialise a cluster structure. Then all extended regions above the initial region are tested for overlap. If any region does not overlap with the coordinates of the cluster, then the cluster coordinates are updated to include the region and the region is marked as clustered. Whenever a new region is added to a cluster, all remaining unclustered regions become possible cluster candidates again. Thus the list of

regions is traversed again from the bottom of the image. Although the regions in the list which have already been marked as clustered can be skipped, this is considered sub-optimal. Once the entire list of regions have been traversed without any overlap detected, the next cluster is begun with the lowest remaining region. The clustering process continues in this manner until no regions are left unclustered. The list of clusters are then unextended and passed to the label task.

[0068] In performing region extension, regions are extended by a variable amount in the vertical direction, but extended by a standard amount in the horizontal direction, with reference to the APA coordinate axis. Horizontal extension is unnecessary during daytime segmentation, as a vehicle blobs tend to be connected across the full width of the vehicle. It is in the vertical direction that blobs due to the same vehicle appear disconnected. For example, two blobs that typically represent a car might be due to its bonnet and its roof. These two blobs will stretch over the full width of the vehicle, and appear one above the other. Furthermore, so long as one blob for each vehicle stretches the full width, the cluster coordinates will be wide enough to incorporate any blobs that might otherwise need horizontal extension to be clustered together. The full width blob provides the extension. With reference to the example illustrated in Figure 20, the region 210 becomes added to the region 212 on the right, from which the cluster 214 is begun, only because the full width region 216 above was added to the region 212 to form the cluster 214. If the region list was not researched from the beginning of the list continuously, the overlap of the previously tested region 210 would not have been found. It is for this reason that the clustering task, as discussed above, reconsiders all unclustered regions after adding a region.

[0069] The cluster task is able to perform one of two extension methods. The first method takes the vertical or Y coordinate of the region as an input to a look-up table that specifies the amount of extension to be applied. The amount of the extension, and hence the degree of clustering, is then modified according to lighting conditions. As the outside light level decreases, and regions reduce in size, the amount of extension applied to regions can be gradually increased. Furthermore, the perspective in the image can be compensated for by adjusting the values stored in the look-up table accordingly, i.e. distant regions high in the camera image can be extended less than near regions which are low in the image. An example of the extension values stored in the look-up table is illustrated by the graph 218 shown in Figure 21 of extension amount v. Y coordinates. All extension amounts are provided in pixel numbers. The second extension method extends each region by an amount proportional to its width. The method is largely based on an observation of the shapes of regions obtained during daytime segmentation. Small regions, which are typically far away, are minimally extended, large vehicle body regions, which are typically close, square and occur:one per vehicle, are minimally extended, and wide short regions, which are often vehicle fronts, are greatly extended. Essentially, as illustrated in Figure 22, this results in every region boundary 220 and 222 being approximately square. In Figure 22, the boundaries 220 and 222 of both regions 224 and 226 have been extended vertically to equal at least their width. Therefore the wide short region 224 has been extended a great deal more than the large square region 226. Region 224 would be a vehicle front portion disposed under the vehicle body region 226. Therefore, the two regions 224 and 226 can be matched without too much extension. If the large region 226 is over extended, then it may overlap with a succeeding vehicle front. In the preferred embodiment, this method is only employed during daytime segmentation as night time processing requires a large amount of region extension, although it is envisaged the extension factor used in the extension calculation can be enlarged for night time use.

[0070] During night time clustering all of the regions to be clustered are essentially small circles, and a truck cluster, for example, is constructed by considering the possibility of whether each light could feasibly fit into a stored truck template. For the first region in a cluster, to fit within the template, there is a maximum distance of light separation which cannot be exceeded.

[0071] Overlap of regions is detected by comparing the coordinates of regions and clusters, wherein the top-left (x_1, y_1) and bottom-right (x_2,y_2) coordinates for both regions and clusters are known. For the image plane coordinates, x increases from left to right and y increases from top to bottom. Considering first the horizontal, x coordinate, overlap for the regions R_1, R_2, R_3, R_4, R_5 and R_6 illustrated in Figure 23 the test for overlap with the cluster C_n is:

$$R_n(x_1) < C_n(x_2) \quad (10)$$

$$C_n(x_1) < R_n(x_2) \quad (11)$$

[0072] If both of the two equations are true, then there is overlap in the horizontal direction. Therefore, horizontal overlap is true for R_2, R_3, R_4 and R_5 but region R_1 fails the test as equation 10 is not true and region R_6 fails the test as equation 8 is not true. A similar test is performed in the vertical direction as follows:

$$R_n(y_2) > C_n(y_1) \quad (12)$$

[0073] There is no need to perform the complimentary test for $R_n(y_1)$ because the regions are outputted from the APA board 80 in order from top to bottom and as the cluster task processes all regions in a list from the bottom up, the complimentary test, $C_n(y_2) > R_n(y_1)$, is unnecessary as it will always be true.

[0074] Clustering during day lighting conditions is based on the overlap test discussed above, yet during dusk and night conditions clustering involves consideration of additional rules, primarily due to the increased ambiguity and greater separation between regions of the same vehicle. Certain regions should also never be clustered, such as headlight reflections and noise from background image areas due to vibration of the detection camera 6 discussed previously. Clustering therefore also involves consideration of a series of rules based on the various region classifications discussed previously. The rules include:

(i) An extended region must spatially overlap a cluster to be added to that cluster.
(ii) If a region overlaps more than one cluster, then it is added to the lowest cluster.
(iii) A region to be clustered cannot already have been added to the cluster.
(iv) A "joined headlights" region cannot be added to an existing cluster. Regions of this type can only initiate a cluster.
(v) Only a predetermined number of "headlight" regions can be added to a cluster, the predetermined number being a system parameter which can be adjusted from the user interface.
(vi) As many "other" and "small light" regions as is spatially allowed can be added to a cluster.
(vii) A region which touches or includes part of the top of the processing window can initiate a cluster but cannot be added to a cluster.
(viii) A further "headlight" region to be added to a cluster must be horizontally aligned with another "headlight" region in that cluster, which is determined on the basis of the difference between the regions lower Y coordinates.
(ix) "Reflection" and "road artefact" regions are not added to any cluster.

[0075] For monitoring a roadway, clusters are classified into one of three classes: car, ute (a small flat-bed utility truck) or truck. Therefore all large vehicles, such as buses and articulated vehicles, are classified as a truck. Cluster classification is based on the height and width of each cluster box, and the number of lights within the cluster during night conditions. The height and width data for each classification is modified via procedure calls to the histogram task 190 as the lighting conditions change from day to dusk and to night, etc. The cluster width is as important as the cluster height because, for example, a large four wheel drive vehicle towing a trailer might produce a cluster which exceeds the truck height threshold but is unlikely to be as wide as a truck or bus. A histogram of cluster heights and widths of motor vehicles includes distinct peaks which correspond to various vehicle classes, and is used to set the stored classification thresholds automatically. The height and width histogram is shown in the display of Figure 16. For example, a cluster is classified as a truck if one of the following conditions is true:

(i) The cluster height and width exceed the truck threshold.
(ii) The lighting condition is night and the cluster exceeds the truck width threshold.
(iii) The lighting condition is night and the number of small lights in the cluster exceeds the small light truck threshold.
(iv) The cluster height is within a predetermined range of the truck height threshold and the number of small light regions in the cluster exceeds the truck small light threshold.

[0076] As ambient lighting drops, the size of the truck clusters are reduced, and consequently the height and width thresholds decrease, depending on the lighting conditions, as determined by the histogram task 190. The classification for each cluster is stored in a clustered data structure, together with the cluster's coordinates and time stamp. The clustered data is then passed to the label task 178.

[0077] The label task 178 assigns a label to each unique cluster and tracks clusters over time by matching an array of previously seen clusters to each subsequent video field of clusters. If a cluster appears in roughly the same place as a cluster from a previous field, then the label task 178 considers them to be the same cluster. Where a match can be made, the new cluster inherits the unique label of the previously seen cluster. If a cluster cannot be matched, then a new label is created for that cluster. Clusters may disappear for a few fields, and it is an objective of the label task 178 to determine whether a cluster is indeed new or whether it has just appeared again after a period of absence.

[0078] The matching of clusters is based on location. Cluster size can be used as an extra match parameter but the current location heuristic has been found sufficient. It can be assumed the clusters will not move very far from their position in the previous field, and if a cluster moves so far that its boundary coordinates in the present frame do not

overlap with its boundary coordinates from the previous frame, then the previous label will not be transferred. Clusters can split and join, both vertically and horizontally, as they are tracked from field to field. Two labelling methods have been developed, with the second being the preferred method which is presently used.

[0079] The first labelling method involves two reciprocal tests which are used to determine whether a new cluster should inherit an old cluster's label. The first test is to determine whether the centre of a new cluster 230 lies within the boundary of any clusters 232 and 234, as shown in Figure 24, on a list of previously seen clusters, called the label list. For the cluster 230, the test fails, but for the new clusters 236 and 238 their centres fall within the older cluster 240 so the lowest new cluster 238 inherits the label of the old cluster 240, and the upper new cluster 236 is assigned a new label. The second test, which is executed when the first test fails, determines whether the centres of any of the clusters on the label list lie within the boundaries of the clusters from the current video field. Therefore as the centres of the old clusters 232 and 234 fall within the boundaries of the new cluster 230, a match is detected, and the new cluster 230 inherits the label of the lower old cluster 234. Applying the second test to the new clusters 236 and 238 results in failure as the centre of the old cluster 240 does not lie within any of the new clusters 236 and 238, and therefore applying this test to these clusters would result in the new clusters 236 and 238 both being assigned new labels.

[0080] The second labelling method is based on the clustering overlap technique described previously. Essentially, the bounding box of each cluster from the current field is tested for an overlap with clusters in the cluster list. The cluster list is search from bottom to top, in a similar manner to the search method described for detecting overlapping regions. In this way, if two clusters merge into a single cluster, then the first overlap found will be an overlap with the lower cluster. Once a match is found, the search is terminated, and the label which is transferred is marked as applied to a new cluster. Therefore a label cannot be transferred twice within one search of a new video frame. The second method is preferred as it requires half the number of tests as the first method, and a cluster can move further between successive frames yet still inherit its label. In the first method, where centres are matched to the boundaries, the maximum displacement allowed between fields is half the width (or height) of the clusters, whereas in the second method, where boundaries are checked for overlap, the maximum displacement is the entire width (or height) of the cluster. Therefore the second method allows a cluster to move twice the distance of the first method.

[0081] As clusters travel successive fields in time, they tend to split or join, and if a cluster splits, then the label is transferred to the lower of the two clusters, and the upper cluster, which would typically be another vehicle behind the lower cluster, is provided with a new label. Alternatively, if two clusters join, then the old lower cluster's label is transferred to the new combined cluster, and the other cluster's label is allowed to expire. The label of the lower of two clusters is transferred after a split or join because the lowest cluster is most likely to include the front of a vehicle, and is therefore given priority with regard to maintaining cluster labels.

[0082] A record of the bounding box coordinates is maintained for each cluster in the cluster list, together with its label, the labels age, and when the cluster was last seen. Whenever a label is inherited, its age increases, and its last scene value is reset. If a label is not transferred in the course of one field, its last scene value is incremented. A label is removed from the cluster list if its last scene value exceeds a label tenure threshold. Cluster labels, coordinates and classifications are passed to the trajectory task 180.

[0083] The trajectory task 180 uses the received cluster data to track the clusters over successive video fields. The coordinates used for tracking a cluster box are the coordinates of the centre of the base of the box, and the coordinate system for the roadway 16 which is adopted is illustrated in Figure 25. The datum 300 of the roadway coordinate system is an arbitrary point on the roadway, which has been chosen as the centre of the left hand fog line underneath the edge of an overpass bridge holding the cameras 6 and 8. Vehicles 302 travel in the positive Y axis direction on the roadway 16, starting at a negative value in the distance. The trajectory of a cluster box in image plane coordinates (x_i, y_i), as shown in the graph of Figure 26 is not linear with time due to the effect of perspective. Therefore a camera transformation is applied so as to convert image plane coordinates to real world 3-D coordinates. In matrix form, the overall camera transformation is as follows:

$$\begin{bmatrix} x^i \\ y^i \\ z^i \end{bmatrix} = \begin{bmatrix} \alpha_x & 0 & X_0 & 0 \\ 0 & \alpha_y & Y_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1/f & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} {}^{0}T_{CAM}^{-1} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad (13)$$

where

α_x X-axis scaling factor in pixels/mm (intrinsic)

α_y Y-axis scaling factor in pixels/mm (intrinsic)
X_0 image plane offset in pixels (intrinsic)
Y_0 image plane offset in pixels (intrinsic)
f focal length (intrinsic)
${}^{0}T_{CAM}$ detection camera 6 position in world coordinates (extrinsic)

[0084] The intrinsic parameters are innate characteristics of the camera and sensor, while the extrinsic parameters are characteristics only of the position and orientation of the camera. The principle point of the image plane is the intersection of the optical axis and that plane, at coordinates (X_0, Y_0). Equation 13 can be written as:

$$\begin{bmatrix} x^i \\ y^i \\ z^i \end{bmatrix} = C \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad (14)$$

where C is the camera calibration matrix, a 3 x 4 homogeneous transform which performs scaling, translation and perspective correction. The image plane coordinates are then expressed in terms of homogeneous coordinates as:

$$X^i = \frac{x^i}{z^i} \qquad (15)$$

$$Y^i = \frac{y^i}{z^i} \qquad (16)$$

[0085] The general perspective transform maps a ray in three dimensional space to a point on the image plane. For vehicle coordinates in the image plane as seen by the detection camera 6, a unique three dimensional location of the vehicle cannot be determined so the bottom of a cluster box received from the label task is considered to be on the roadway, i.e. z = 0, and therefore the box can be tracked with reference to the roadway x and y coordinates. The equations 14, 15 and 16, given the image plane coordinates and z, can be solved simultaneously for the roadway coordinates x and y to specify the position of a vehicle. The equations have been solved using the computer algebra package MAPLE, and the solution, in C notation, is as follows:

```
den = (-Xi*C31*C22+Xi*C32*C21+(Yi*C21-C21)*C12+(-Yi*C32+C22)*C11);

y = -(-Xi*C31*C24+Xi*C34*C21+(Yi*C21-C21)*C14 +
(Xi*C33*C21-Xi*C31*C23)*z+(Yi*C31-C21*z*C13+
(-Yi*C34+C24+(-Yi*C33+C23)*z)*C11)/ den;

x = (-C24*Xi*C32+C22*Xi*C34+(Yi*C32-C22)*C14+
(C22*Xi*C33-C23*Xi*C32)*z+
(Yi*C32-C22)*z*C13+(-Yi*C34+C24+(-Yi*C33+C23)*z)*C12) / den;
```

[0086] The solution explicitly includes height above the roadway, z, which can be set at zero for daytime operation or some marginal distance above the roadway, whereas at night, the bottom of the cluster box generally corresponds to the height of the headlights above the road, and therefore z is set to a notional headlight height. Figure 27 illustrates a graph of the same vehicle trajectory as in Figure 26, after the trajectory has been mapped to the roadway coordinates x and y. The trajectory illustrates the vehicle is moving at a constant speed, and in the left hand lane.

[0087] The time at which the vehicle 302 will reach the acquisition line 22, and the future location of the vehicle 302, need to be predicted, due to latency in the system. Considerable latency exists between a trigger request and image acquisition via the acquisition camera 8, and additional latency is caused by pixel transfer, image processing pipeline delay and software processing delay. The information obtained on the basis of the images required by the detection camera 6 provide a delayed representation of the actual vehicle position, and therefore it is necessary estimate the future position and speed of the vehicle 302.

[0088] The position estimates of a vehicle obtained by the inverse perspective discussed above are quite noisy due to quantisation effects, particularly when vehicles are in the distance, therefore simple differencing cannot be used to estimate velocity of a vehicle and therefore the software uses a Kalman filter to reconstruct the vehicle's lateral and longitudinal position and velocity states, based on the noisy observations of the vehicle position. The vehicle state for each of the longitudinal and lateral axes comprises position ω and speed $\dot{\omega}$ of the vehicle, represented as follows:

$$\underline{X} = [\omega \ \dot{\omega}]^T \tag{17}$$

[0089] In space state form, assuming constant velocity motion, the vehicle dynamics are

$$\dot{\mathbf{X}} = \Phi\mathbf{X} \tag{18}$$

$$\underline{Y} = C\underline{X} \tag{19}$$

where $\underline{Y}$ is the observable output of the system, being the vehicle's lateral or longitudinal position, Φ is the state-transition matrix, and C is the observation matrix. For constant velocity motion the matrices are as follows:

$$\Phi = \begin{bmatrix} 1 & T \\ 0 & 1 \end{bmatrix} \tag{20}$$

$$C = [1 \ 0] \tag{21}$$

where T is the sampling interval, being equal to the video field interval which is 20 ms. The Kalman filter equations for one axis are

$$K = \Phi P C^T (C P C^T + R_2)^{-1} \tag{22}$$

$$\hat{X} = \Phi X + K(y - CX) \tag{23}$$

$$P = \Phi P \Phi^T + R_1 I_2 - K C P \Phi^T \tag{24}$$

[0090] The filter is predictive, and $\hat{X}$ is the predictive value of the vehicle state for the next sample interval. K is a gain, P is the error co-variance matrix, and I_2 is a 2 × 2 identity matrix. R_1 and R_2 are input and output co-variance estimates, and are used to adjust the dynamics of the filter.

[0091] The Kalman filter equations 22, 23 and 24 are complex and time consuming to execute in matrix form, and the computer algebra package MAPLE was used to reduce the equations to scalar form, as follows, in C notation:

```
/* compute the filter gain */
den = kp->p11 + *R2;
k1 = (kp->p11 + T * kp->p12) / den
k2 = kp->p12 / den;
```

```
/* update the state vector */
x1 = kp->x1 + T * kp->x2 +k1 * (*y - kp->x1);
x2 = kp->x2 + k2 * (*y - kp->x1);

kp->x1 = x1;
kp->x2 = x2;

/* update the covar matrix (symmetric so keep only 3 elements) */
p11 = *R1 + kp->p11 + 2.0 * T * kp->p12 + T * T * kp->p22 - k1 * kp->p11 - k1 * kp->p12 * T;
p12 = kp->p12 + T * kp->p22 - k1 * kp->p12;
p22 = *R1 + kp->p22 - k2 * kp->p12;

kp->p11 = p11;
kp->p12 = p12;
kp->p22 = p22;
```

[0092] The estimated values for the state of the vehicle and error covariance for the filter are calculated using the equations and are stored in a data structure *kp. Optimal values for R_1 and R_2 are determined empirically. Figure 28 illustrates graphs which can be plotted from the estimated values for one axis, being the estimated position and estimated speed of the vehicle, and the estimated error associated with the camera filter calculations, as each video field is received. The estimated acquisition time is calculated by using the estimated vehicle state data. As the position 22 at which acquisition to occur is known, the estimated acquisition time is calculated by taking the difference between the estimated position and the acquisition position, and dividing the result by the estimated velocity of the vehicle. When the estimated acquisition time falls below a value which indicates acquisition is to occur within the time of the next video field then the estimated time information is provided to a trigger board 84. The estimated vehicle state coordinate for the x direction indicates which camera 8 of a multi-lane carriageway is to be triggered.

[0093] The scaling matrix C of equation 14 may be calibrated using road markers or preferably telescopic stakes which are placed at predetermined positions along the roadway 16. The stakes are surveyed with respect to the roadway datum 300 to obtain the x, y and z coordinates for different positions on the stakes, and then removed. Equation 14 can be expanded as follows:

$$C_{11}x + C_{12}y + C_{13}z + C_{14} - C_{31}X'x - C_{32}X'y - C_{33}X'z - C_{34}X' = 0 \tag{25}$$

$$C_{21}x + C_{22}y + C_{23}z - C_{24} - C_{31}Y'x - C_{32}Y'y - C_{33}Y'z - C_{34}Y' = 0 \tag{26}$$

which relate an image plane coordinate (X',Y') to a real world coordinate (x,y,z). For n observations this can be expressed in matrix form as follows:

$$\begin{bmatrix} x_1 & y_1 & z_1 & 1 & 0 & 0 & 0 & 0 & -X'_1x_1 & -X'_1y_1 & -X'_1z_1 \\ 0 & 0 & 0 & 0 & x_1 & y_1 & z_1 & 1 & -Y'_1x_1 & -Y'_1y_1 & -Y'_1z_1 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ x_n & y_n & z_n & n & 0 & 0 & 0 & 0 & -X'_nx_n & -X'_ny_n & -X'_nz_n \\ 0 & 0 & 0 & 0 & x_n & y_n & z_n & n & -Y'_nx_n & -Y'_ny_n & -Y'_nz_n \end{bmatrix} \begin{bmatrix} C_{11} \\ C_{12} \\ \cdot \\ \cdot \\ \cdot \\ C_{33} \end{bmatrix} = \begin{bmatrix} X'_1 \\ Y'_1 \\ \cdot \\ \cdot \\ \cdot \\ X'_n \\ Y'_n \end{bmatrix} \tag{27}$$

[0094] The equations are homogeneous and therefore the overall scaling of the C matrix is simply chosen so that $C_{34} = 1$, and this parameter is not identified. Equation 27 has 11 unknowns and for a solution requires at least 5.5 observations, being pairs of (X',Y') and (x,y,z). The system of equations is generally over determined, and a least

426, as shown in Figure 39. The locate plate module 420, as shown in Figure 40, begins at step 430 by preparing the 1280 × 1024 pixel image for processing as a number of pixel windows for the Pixar co-processor 402. At step 432, the system 51 attempts to detect an edge of a character size object, and when detected the object's location is determined at step 434. An object assembler is used at step 436 to group adjacent objects together, and the groups are processed by a plate classifier 438 to determine whether the object groups could constitute a licence plate. If an object group is classed as a plate according to a plate template, a bounding box is formed, and its coordinates returned to the glyph extraction module 422. The glyph extraction module 422 processes each bounding box to binarise and extract individual characters in a bounding box and then pass the "glyphs", i.e. licence plate letters and numbers, to the OCR module 424. The OCR module 424, as shown in Figure 41 begins at step 428 by building a typological graphical representation of a glyph from the glyph bitmap provided by the glyph extraction module 422 for each glyph. The graphical representation is analysed at step 440 so as to detect any characteristic features, such as holes, arcs and vertical and horizontal lines. From the results of step 440 an 81 bit string representing the characteristic features of the glyph is created at step 442. A bayesian statistical analysis is then performed at step 444 on the feature string to try and match the features against a set of previously determined features characteristic of known ASCII characters. The ASCII value of the match with the highest probably of being correct is returned to the plate recognition module 426.

[0115] The plate recognition module 426 determines whether the glyphs in a bounding box constitute a valid licence plate. The module 426 effectively controls the other image processing modules as it has the ability to override the results of the OCR module 424 or to force the glyph extraction module 422 to use a bounding box other than that found by the locate module 420. The majority of vehicle licence plates in Australia have six characters and fall into one of two classes, Federal plates or non-Federal plates. Federal plates comprise two alphabetic characters, two digits and two alphabetic characters, whereas non-Federal plates comprise three alphabetic characters and are followed by three digits. The plate recognition module 426 is able to determine whether a valid licence plate has been found on the basis of this information, and other information, such as the spacing of characters and the specific characteristic alphanumeric sequences used by the non-Federal plates. The OCR module, for example, may not be able to distinguish between capital B and 8, and for many plate fonts, there is no difference between a 0 and O or a 1 and an I. Therefore the plate recognition module 426 may need to override the results obtained by the OCR module 424. The plate recognition module 426 is also able to instruct the glyph extraction module 424 to process an altered bounding box if the module 426 determines that there may be additional glyphs to the left or right of an original bounding box returned by the locate module 420. The licence plate details obtained by the plate recognition module 426 are stored on DatabaseQ 415 of the server 47, and archived on the optical disk 410. The optical disk 410 also archives image files which the system 51 is unable to process when received.

[0116] The database on the optical disc 410 stores for each processed image as does DatabaseQ 415, data concerning the position, size and characters of the numberplate located in the image, and other details such as time and date of acquisition. It is also structured with data pointers which facilitate access to the stored data by the workstation 400. The workstation 400 includes graphical user interface software which enables an operator to review the results of the procedures 412 and 414, and perform further optical character recognition on numberplate regions, as selected. Any further OCR processing performed on a plate region selected by the operator of the workstation 400 is normally used to analyse the performance of the procedures 412 and 414 and not to alter the integrity of the data held in the optical disc 410.

[0117] The image data stored on database 421 is processed by matching software which looks for matches amongst the licence plate details fields of the image data so as to locate occurrences of detection of the same licence plate at different remote sites or nodes 2. Once a match has been located, the acquisition time fields can be used to determine whether speed or time violations have occurred in travel between remote sites 2, as distance between the sites 2 is known. The matching software is run on a Sun Microsystems workstation 450 connected to the LAN 419, or alternatively, the matching software is run on a system of a road traffic authority, with the image data being sent by the central server 47 over the ISDN 45 to the road traffic authority. The road traffic authority is able to communicate with the central server 47 via the ISDN 45 to obtain archived images, as required.

[0118] To avoid sending all images to the central server 47, a large number of which may not be of interest, images can be archived at the nodes 2, and licence plate details extracted at the remote nodes 2 by respective licence plate recognition systems 51 connected directly to the BIT3 repeater cards 89 of a node's acquisition sub-system 68. The server 47 then only receives the extracted licence plate details, and other data on the image, such as acquisition time, the remote site, and instantaneous speed, and not the image itself. Images archived at the remote sites 2 can be retrieved by the central server 47 when required.

[0119] Control of the remote nodes 2 is performed by the remote site user interface 53 which runs on the Sun workstation 450 connected to the LAN 419 of the central server 47. The interface 53 includes a user tool which communicates with a super task of each remote site 2 using a Sun Microsystems Remote Procedure Call (RPC) communications protocol. The super task provides a set of procedural functions which can be called by the user tool using the RPC protocol, regardless of the location of the workstation 450. The RPC protocol handles data type conversions and align-

ment. The procedures provided by the super task perform various aotions which together allow complete control of the software of a node 2. For example, a parameter file maintains a list of all variables used by the software of the nodes 2, together with their initial values. The form of the values indicates the variable type, which may be a decimal integer, a hexadecimal integer, a floating point value, a character string or boolean value. The variables can be altered by adjusting the parameter file, and location of the variables listed in the parameter file is done via a VxWorks systems table which contains all global symbols. The user tool, in addition to changing system parameters, can access the super task to obtain status and configuration information on each node 2.

[0120] The super task accepts RPC transactions via both the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP), both of which use the Internet protocol (IP) for transmission of datagrams between computer systems. UDP is connectionless protocol which primarily involves multiplexing of datagrams, whereas TCP is a connection orientated protocol which seeks to ensure data integrity is maintained. The user tool presently uses TCP/IP which, together with the RPC protocol, is provided with Sun Microsystem's SunOs operation system and the VxWorks real time operating system. To protect against different central stations accessing a remote node and making conflicting changes to system parameters, the user tool provides information on the current state of the node software before any alteration can be made.

[0121] The master clocks 354 of the remote sites 2 are synchronised to the clock of the central server 47, and the systems 51 and 450 connected to the LAN 491 using a network time protocol (NTP), which is a standard UNIX utility normally used to synchronise the clocks of stations on a LAN. The NTP polls the remote sites 2 and on the basis of information received from the sites 2 concerning communications between the sites and the server 47, the NTP applies offsets to the remote sites 2 so as to synchronise the sites 2 and account for network propagation delays, including transient network problems such as link congestion.

[0122] The vehicle monitoring system is particularly advantageous as it is able to detect and discriminate moving vehicles from other objects, and acquire an image of selected vehicles from which they can be identified, using only electronic cameras and processing circuitry and software housed at a remote site 2. The system enables automatic extraction of licence plate details and does not require road based equipment or markings, the emission of electromagnetic signals or the replacement of film at the node 2.

[0123] The system is able to simultaneously track a number of vehicles on multi-lane carriageways and classify them by vehicle type. A high resolution image of a vehicle can be obtained over a full traffic lane, the resolution and clarity of the invention being sufficient to enable extraction of the licence plate details. The system can operate continuously in all conditions where visibility is greater than 100 metres, using infrared imaging techniques. The high resolution camera incorporates antiblooming technology to prevent pixel saturation due to vehicle headlights, and the infrared flash used is configured so as to be substantially undetectable and inhibit flash dazzle.

[0124] The system can also be controlled and initialised from a remote central station, with images and data being transmitted over a digital communications network.

[0125] The system can further be used for a number of purposes, such as monitoring tailgating offences, road toll collection, and transit lane monitoring. It can also be adapted for red light intersection monitoring.

[0126] The system can also be adapted to monitor and acquire images of other moving objects, such as the movement of shipping containers within transport depots, and the movement of objects on an assembly line.

Claims

1. An object monitoring system comprising camera means (6,8,30,34), characterised in that the camera means is adapted to monitor movement of an object (18) to predetermine, based on the monitored movement of the object, an acquisition time at which an image can be acquired at a predetermined position (22) of said object relative to said camera means, and to acquire an image at the predetermined acquisition time and the predetermined position.

2. An object monitoring system as claimed in claim 1, wherein said camera means (6,8,30,34) is adapted to detect said object (18) and discriminate said object from static objects and other moving objects.

3. An object monitoring system as claimed in claim 2, wherein the camera means (6,8;30,34) includes video camera means (6) for monitoring a respective area (12) in which objects move, and image processing means (30) for subtracting a background image of said area from images of said area generated by said video camera means so as to produce difference images representative of moving objects in said area.

4. An object monitoring system as claimed in claim 3, wherein said image processing means (30) includes classification means (80) for forming clusters from parts of said difference images which correspond to the same moving object (18).

13. Objektüberwachungssystem nach Anspruch 12 mit einer Lichtintensitätsvorrichtung (190) zum Überwachen eines Lichtwerts des Gebiets, wobei der bestimmte Wertebereich, die Analyse der Bereiche, die auf die Bereiche durch die Clustererzeugungsvorrichtung (174) angewandte Ausdehnung und die Klassifizierungsdaten in Abhängigkeit von dem Lichtwert eingestellt werden.

14. Objektüberwachungssystem nach Anspruch 13, bei dem die Bildverarbeitungsvorrichtung eine Vorrichtung (180) zum Verfolgen der dem Objekt entsprechenden Cluster bei aufeinanderfolgenden Bilder aufweist, die eine Transformationsvorrichtung zum Transformieren von Koordinaten der Cluster zum Kompensieren eines perspektivischen Blicks der Kameravorrichtung und eine Vorrichtung zum Vorraussagen der Geschwindigkeit und Position des Clusters für jedes folgende Bild umfaßt.

15. Objektüberwachungssystem nach Anspruch 14, bei dem die Verfolgungsvorrichtung (180) die Erfassungszeit auf der Basis der bestimmten Position (22) und der vorhergesagten Geschwindigkeit und Position des Clusters bestimmt.

16. Objektüberwachungssystem nach Anspruch 15, bei dem die Kameravorrichtung (6, 8, 30, 34) eine Bilderfassungskameravorrichtung (8, 34) aufweist, um das Bild des Objektes (18) bei der Erfassungszeit zu erhalten.

17. Objektüberwachungssystem nach Anspruch 16, bei dem die Bilderfassungskameravorrichtung (8, 34) eingerichtet ist, um ein hochauflösendes Bild des Objektes zu erhalten.

18. Objektüberwachungssystem nach Anspruch 17, bei dem die Videokameravorrichtung (6) ein relativ zu der Bilderfassungskameravorrichtung (8, 34) weites Blickfeld (12) hat, die ein eingeschränktes Blickfeld (20) aufweist.

19. Objektüberwachungssystem nach Anspruch 18 mit einem Infrarotblitz (40), der mit der Bilderfassungskameravorrichtung (8, 34) synchronisiert ist, wobei der Energiewert des Blitzes von dem Lichtwert abhängt.

20. Objektüberwachungssystem nach Anspruch 19, bei dem die Bilderfassungskameravorrichtung (8, 34) eine Bildwahrnehmungsvorrichtung (371) und eine Belichtungsregelvorrichtung (40) zum Verhindern einer Sättigung der Bildwahrnehmungsvorrichtung als Reaktion auf den Lichtwert aufweist.

21. Objektüberwachungssystem nach Anspruch 20, bei dem der Blitz eine Vorrichtung zum Unterdrücken der Emission sichtbaren Lichts vom Blitz aufweist.

22. Objektüberwachungssystem nach Anspruch 21, bei dem die durch die Clustererzeugungsvorrichtung (174) angewandte Ausdehnung zunimmt, wenn der Lichtwert einem Nachtzustand entspricht.

23. Objektüberwachungssystem nach Anspruch 22, bei dem die Ausdehnung für Bereiche geringer ist, die Objekten entsprechen, die fern von der Kameravorrichtung (6, 8) sind.

24. Objektüberwachungssystem nach Anspruch 23, bei dem die Markierungsvorrichtung (178) das Vergleichen und Trennen auf der Basis des Vergleichens von Grenzen oder Zentren der Cluster von aufeinanderfolgenden Bilder durchführt.

25. Objektüberwachungssystem nach Anspruch 24, bei dem die Differenzbilder gefiltert und eingesetzt werden, um das Hintergrundbild zu aktualisieren.

26. Objektüberwachungssystem nach Anspruch 25 mit einer Vorrichtung (84) zum Auslösen der Bilderfassungskameravorrichtung (8, 34) bei der Erfassungszeit, die eine Vorrichtung (352) zum Empfangen und Speichern einer Zahl einer Abtastlinie, die der Erfassungszeit der Verfolgungsvorrichtung (180) entspricht, eine Vorrichtung (358) zum Zählen der Abtastlinien der Bilder und eine Vorrichtung (356) zum Erzeugen eines Auslösesignals für die Bilderfassungskameravorrichtung aufweist, wenn der Zählwert die Zahl erreicht.

27. Objektüberwachungssystem nach Anspruch 26, bei dem die Lichtintensitätsvorrichtung (190) ein Histogramm (150) von Grauwerten von Bildpunkten für die von der Videokameravorrichtung erzeugten Bilder erzeugt und einen Tag-, Nacht- oder Zwielicht-Lichtzustand auf der Basis des Mittelwerts des Histogramms bestimmt.

28. Objektüberwachungssystem nach Anspruch 27, bei dem der bestimmte Wertebereich auf der Basis des Minimums,

des Mittelwerts und des Spitzenwerts des Histogramms bestimmt wird.

29. Objektüberwachungssystem nach Anspruch 28, bei dem die Messungen die Zirkularität und die Überdeckung der Bereiche umfassen.

30. Objektüberwachungssystem nach einem der Ansprüche 1 bis 29 mit einer Erkennungsvorrichtung (51) zum Verarbeiten des erfaßten Bildes, um Informationen zu erhalten, die das Objekt (18) identifizieren.

31. Objektüberwachungssystem nach Anspruch 30 mit mehreren Kameravorrichtungen (6, 8, 30, 34) zum Überwachen jeweiliger Gebiete, die eingerichtet sind, um miteinander zu kommunizieren, um Informationen über das Objekt (18) zu übertragen.

32. Objektüberwachungssystem nach Anspruch 30 oder 31 mit mehreren Kameravorrichtungen (6, 8, 30, 34) zum Überwachen jeweiliger Gebiete, die eingerichtet sind, um mit einer Zentralstation (47) zu kommunizieren, um Informationen über das Objekt (18) zu übertragen.

33. Objektüberwachungssystem nach Anspruch 32, bei dem die Informationen über das Objekt (18) von zumindest zwei Kameravorrichtungen (6, 8, 30, 34) erfaßt werden, und die Informationen eingesetzt werden können, um die Zeit zu bestimmen, die das Objekt braucht, um sich zwischen zumindest zwei der Gebiete zu bewegen.

34. Objektüberwachungssystem nach Anspruch 33, bei dem die Zentralstation (47) eine Fernsteuervorrichtung (53) zum Steuern der Kameravorrichtung von der Zentralstation aus aufweist.

35. Objektüberwachungssystem nach Anspruch 34, bei dem die Zentralstation (47) und die mehreren Kameravorrichtungen (6, 8, 30, 34) jeweilige Telekommukikationskontroller (55) aufweisen und unter Verwendung eines digitalen Telekommunkationsnetzwerkes (45) kommunizieren.

36. Objektüberwachungssystem nach Anspruch 35 mit einer Vorrichtung (49) zum Archivieren der Informationen und zum Gestatten eines anschließenden Zugriffs darauf.

37. Objektüberwachungssystem nach Anspruch 36, bei dem die Informationen erfaßte Bilder des Objektes und die Erfassungszeiten umfassen, und die Zentralstation (47) die Erkennungsvorrichtung (51) aufweist.

38. Objektüberwachungssystem nach Anspruch 36, bei dem die Informationen identifizierende Informationen und die Erfassungszeiten erfaßter Bilder des Objektes (18) umfassen, und mehrere Erkennungsvorrichtungen (51) an die mehreren Kameravorrichtungen (6, 8, 30, 34) jeweils bei den Orten der mehreren Kameravorrichtungen (6, 8, 30, 34) angeschlossen sind.

39. Objektüberwachungssystem nach Anspruch 37 oder 38, bei dem die Erkennungsvorrichtung (51) eingerichtet ist, um das erfaßte Bild zu verarbeiten, um Bildpunkte zu ermitteln, die für charakteristische Bildpunkte kennzeichnend sind, die das Objekt (18) identifizieren.

40. Objektüberwachungssystem nach einem der Ansprüche 1 bis 39, bei dem das Objekt (18) ein Fahrzeug ist.

41. Objektüberwachungssystem nach Anspruch 40 in Abhängigkeit von Anspruch 30, bei dem die Erkennungsvorrichtung eine Vorrichtung zum Ermitteln eines Nummernschilds in dem Bild und eine Vorrichtung zum Bestimmen der Schriftzeichen des Nummernschilds umfaßt, wobei die Schriftzeichen die identifiziernden Informationen umfassen.

42. Objektüberwachungssystem nach Anspruch 41 in Abhängigkeit von Anspruch 6, bei dem der bestimmte Wertebereich Bildpunktwerte abdeckt, die durch Schatten des Fahrzeugs erzeugt werden.

43. Objektüberwachungssystem nach Anspruch 42 in Abhängigkeit von Anspruch 8, bei dem die ungültigen Bereiche Fahrlichtreflektionen entsprechen, die von Fahrzeugen oder Fahrbahnmarkierungen in dem Gebiet erzeugt werden.

44. Objektüberwachungssystem nach einem der Ansprüche 40 bis 43, bei dem das Fahrzeug ein großes Fahrzeug, zum Beispiel ein Bus oder Laster, ist.

45. Objektüberwachungssystem nach einem der Ansprüche 1 bis 44, bei dem das Objekt (18) ein Fahrzeug ist, und bei dem die Kameravorrichtung (6, 8, 30, 34) eingerichtet ist, um das Fahrzeug zu überwachen, um eine Gesetzesverletzung wahrzunehmen, und ein Bild von dem Fahrzeug zu der bestimmten Zeit als Reaktion auf die Wahrnehmung der Verletzung macht.

46. Objektüberwachungssystem nach Anspruch 45 mit einer Erkennungsvorrichtung (51) zum Verarbeiten der Bilder, um Imformationen zu erhalten, die das Fahrzeug identifizieren.

47. Objektüberwachungssystem nach Anspruch 1, bei dem die Kameravorrichtung (6, 8, 30, 34) Bilder von einem Gebiet erzeugt und ein Bild von einem bestimmten Objekt erfaßt, wobei das Objektüberwachungssystem eine Verarbeitungsvorrichtung (30) umfaßt, die folgendes aufweist:

eine Vorrichtung (70, 72, 74, 76) zum Abziehen eines Hintergrundbildes des Gebiets von den Bildern des Gebietes, um Differenzbilder zu erzeugen, die für sich in dem Gebiet bewegende Objekte kennzeichnend sind,

eine Segmentierungsvorrichtung (77, 78) zum Verarbeiten. der Differenzbilder, um Bilder des Bereichs zu erzeugen, die für Bereiche kennzeichnend sind, die Teilen der sich in dem Gebiet bewegenden Objekte entsprechen,

eine Klassifizierungsvorrichtung (80) zum Verarbeiten der Bilder des Bereichs, wobei die Klassifizierungsvorrichtung eine Vorrichtung (176) zum Analysieren der Form der Bereiche und zum Bestimmen gültiger und ungültiger Bereiche auf der Basis der Analyse, eine Clustervorrichtung (176) zum Erzeugen von Clustern auf der Basis der gültigen Bereiche, die jeweiligen der sich bewegenden Objekte entsprechen, und eine Vorrichtung (176) zum Klassifizieren der Cluster durch Vergleichen zumindest einer Charakteristik der Cluster mit Klassifizierungsdaten des Systems aufweist, um festzustellen, ob einer der Cluster dem bestimmten Objekt entspricht, und

eine Verfolgungsvorrichtung (180) zum Verfolgen des einen Clusters, der dem bestimmten Objekt entspricht, um eine Bilderfassungszeit zum Erfassen des Bildes des bestimmten Objektes zu bestimmen.

48. Objektüberwachungssystem nach Anspruch 47, bei dem die Bildverarbeitungsvorrichtung (30) die Differenzbilder filtert, um Bildpunkte in einem bestimmten Intensitätsbereich unberücksichtigt zu lassen.

49. Objektüberwachungssystem nach Anspruch 48, bei dem die Teile des sich bewegenden Objektes zumindest einem bestimmten Lichtwert entsprechen, der bei der Kameravorrichtung (6, 8, 30, 34) empfangen wird.

50. Objektüberwachungssystem nach Anspruch 49, bei dem die Klassifizierungsvorrichtung (80) die gültigen Bereiche ausdehnt, um festzustellen, ob die gültigen Bereiche kombiniert werden müssen, um die Cluster zu bilden.

Revendications

1. Système de surveillance d'un objet comprenant des moyens formés de caméras (6, 8, 30, 34), caractérisé en ce que les moyens formés de caméras sont adaptés pour contrôler des déplacements d'un objet (18) de manière à prédéterminer, sur la base du déplacement contrôlé de l'objet, un instant d'acquisition auquel une image peut être acquise dans une position prédéterminée (22) dudit objet par rapport auxdits moyens formés de caméras, et pour acquérir une image à l'instant d'acquisition prédéterminé et dans la position prédéterminée.

2. Système de surveillance d'un objet selon la revendication 1, dans lequel lesdits moyens formés de caméras (6, 8, 30, 34) sont adaptés pour détecter ledit objet (18) et discriminer ledit objet d'objets statiques et d'autres objets mobiles.

3. Système de surveillance d'un objet selon la revendication 2, dans lequel les lesdits moyens formés de caméras (6, 8, 30, 34) incluent des moyens formés de caméras vidéo (6) pour surveiller une zone respective (12) dans laquelle des objets se déplacent, et des moyens (30) de traitement d'images pour soustraire une image d'arrière plan de ladite zone, d'images de ladite zone produites par lesdits moyens formés de caméras vidéo de manière à produire des images de différence représentatives d'objets mobiles dans ladite zone.

4. Système de surveillance d'un objet selon la revendication 3, dans lequel lesdits moyens (30) de traitement d'images incluent des moyens de classification (80) pour former des regroupements à partir de parties desdites images de différence, qui correspondent au même objet mobile (18).

5. Système de surveillance d'un objet selon la revendication 4, dans lequel lesdits moyens (30) de traitement d'images traitent chaque regroupement pour déterminer s'il correspond audit objet (18) et détermine. ledit instant d'acquisition.

6. Système de surveillance d'un objet selon la revendication 5, dans lequel ledit moyen (30) de traitement d'images filtre lesdites images de différence pour ne pas prendre en compte des pixels dans une gamme predéterminée de niveaux (79).

7. Système de surveillance d'un objet selon la revendication 6 dans lequel lesdits moyens (30) de traitement d'images incluent des moyens de segmentation (78) pour traiter lesdites images de différence de manière à produire des images segmentées qui incluent des régions correspondant à des parties d'objets mobiles dans ladite zone, qui produisent au moins un niveau de lumière prédéterminé dans lesdits moyens formés de caméras.

8. Système de surveillance d'un objet selon la revendication 7, dans lequel lesdits moyens de classification (80) analysent et produisent des mesures de la forme desdites régions et, sur la base de l'analyse et des mesures, déterminent des régions valables et des régions non valables ne devant pas être prises en compte.

9. Système de surveillance d'un objet selon la revendication 8, dans lequel lesdits moyens de classification (80) comprennent des moyens de regroupement (174) pour produire lesdits regroupements, chaque regroupement comprenant des régions valables, qui sont considérées comme correspondant à un objet, lesdites régions étant agrandies pour déterminer si des régions se chevauchent entre elles et doivent être combinées entre elles pour former un regroupement..

10. Système de surveillance d'un objet selon la revendication 9, dans lequel lesdits moyens de classification (80) comprennent des moyens d'étiquetage (178) pour affecter une étiquette à chaque regroupement pour chaque image de manière à identifier des regroupements respectifs, et pour mettre en correspondance et séparer des regroupements dans des images successives pour déterminer si des étiquettes doivent être héritées ou si de nouvelles étiquettes doivent être affectées.

11. Système de surveillance d'un objet selon la revendication 10, dans lequel lesdits moyens de classification (80) sont adaptés pour classer lesdits regroupements comme correspondant à des objets prédéterminés par comparaison de caractéristiques desdits regroupements avec des données de classification dudit système, de telle sorte que lesdits moyens de classification sont adaptés pour identifier un regroupement correspondant audit objet (18).

12. Système de surveillance d'un objet selon la revendication 11, comprenant des moyens (190) pour maintenir un histogramme (150) desdites caractéristiques pour des objets contrôlés par lesdits moyens formés de caméra (6, 8, 30, 34) et pour ajuster lesdites données de classification sur la base dudit histogramme.

13. Système de surveillance d'un objet selon la revendication 12, comprenant des moyens (190) de réglage de l'intensité lumineuse servant à contrôler un niveau d'éclairement de ladite zone, et dans lequel ladite gamme prédéterminée de niveaux, ladite analyse desdites régions, l'extension appliquée auxdites régions par lesdits moyens de regroupement (174) et lesdites données de classification sont réglées en fonction dudit niveau d'éclairement.

14. Système de surveillance d'un objet selon la revendication 13, dans lequel lesdits moyens de traitement d'images comprennent des moyens (180) pour réaliser le suivi du regroupement correspondant audit objet dans des images successives, comprenant des moyens de transformation pour transformer des coordonnées dudit regroupement pour compenser une vue en perspective desdits moyens formés de caméras, et des moyens pour prédire la vitesse et la position dudit regroupement pour chacune des images successives.

15. Système de surveillance d'un objet selon la revendication 14, dans lequel lesdits moyens de suivi (180) déterminent l'instant d'acquisition sur la base de ladite position prédéterminée (22) et de la vitesse et de la position prédites dudit regroupement.

16. Système de surveillance d'un objet selon la revendication 15, dans lequel lesdits moyens formés de caméras (6,

8, 30, 34) comprennent des moyens formés de caméras (8, 34) de captage d'images pour acquérir ladite image dudit objet (18) audit instant d'acquisition.

17. Système de surveillance d'un objet selon la revendication 16, dans lequel lesdits moyens formés de caméras (8, 34) de captage d'images sont adaptés pour acquérir une image à haute résolution dudit objet.

18. Système de surveillance d'un objet selon la revendication 17, dans lequel lesdits moyens formés de caméras vidéo (6) possèdent un champ d'observation (12) étendu par rapport auxdits moyens formés de caméras (8, 34) de captage d'images, qui possèdent un champ d'observation limité (20).

19. Système de surveillance d'un objet selon la revendication 18, comprenant une lampe flash infrarouge (40) qui est synchronisée avec lesdits moyens formés de caméras (8, 34) de captage d'images, le niveau d'énergie de ladite lampe flash dépendant dudit niveau d'éclairement.

20. Système de surveillance d'un objet selon la revendication 19, dans lequel lesdits moyens formés de caméras (8, 34) de captage d'images incluent des moyens de détection d'images (371) et des moyens (40) de commande d'exposition pour empêcher une saturation desdits moyens de détection d'images en réponse audit niveau d'éclairage.

21. Système de surveillance d'un objet selon la revendication 20, dans lequel ladite lampe flash inclut des moyens pour empêcher l'émission d'une lumière visible par la lampe flash.

22. Système de surveillance d'un objet selon la revendication 21, caractérisé en ce que ladite extension appliquée par lesdits moyens de regroupement (174) est augmentée lorsque ledit niveau d'éclairement correspond à une condition de nuit.

23. Système de surveillance d'un objet selon la revendication 22, dans lequel ladite extension est inférieure pour des régions correspondant à des objets distants desdits moyens formés de caméras (6, 8).

24. Système de surveillance d'un objet selon la revendication 23, dans lequel lesdits moyens d'étiquetage (178) exécutent ladite mise en correspondance et ladite séparation sur la base d'une comparaison de limites ou de centres desdits regroupements pour des images successives.

25. Système de surveillance d'un objet selon la revendication 24, selon lequel lesdites images de différence sont filtrées et utilisées pour mettre à jour ladite image d'arrière-plan.

26. Système de surveillance d'un objet selon la revendication 25, comprenant des moyens (84) pour déclencher lesdits moyens formés de caméras (8, 34) de captage d'images audit instant d'acquisition, comprenant des moyens (352) pour recevoir et mémoriser un nombre de ligne de balayage correspondant audit instant d'acquisition à partir desdits moyens de suivi (180), des moyens (358) pour compter des lignes de balayage desdites images et des moyens (356) pour produire un signal de déclenchement pour lesdits moyens formés de caméras de captage d'images lorsque ledit comptage atteint ledit nombre.

27. Système de surveillance d'un objet selon la revendication 26, dans lequel lesdits moyens (190) de réglage de l'intensité lumineuse produisent un histogramme (150) de niveaux de gris de pixels pour lesdites images produites par lesdits moyens formés de caméras vidéo et déterminent une condition d'éclairement de jour, de nuit ou au crépuscule, sur la base de la médiane dudit histogramme.

28. Système de surveillance d'un objet selon la revendication 27, dans lequel ladite gamme prédéterminée de niveaux est déterminée sur la base du minimum, de la médiane et du pic dudit histogramme.

29. Système de surveillance d'un objet selon la revendication 28, dans lequel lesdites mesures comprennent une circularité et une surface de couverture desdites régions.

30. Système de surveillance d'un objet selon l'une quelconque des revendications 1 à 29, comprenant des moyens de reconnaissance (51) pour traiter l'image acquise pour obtenir une information identifiant ledit objet (18).

31. Système de surveillance d'un objet selon la revendication 30, comprenant une pluralité desdits moyens formés

de caméras (6, 8, 30, 34) pour surveiller des zones respectives, et adaptés pour communiquer entre eux de manière à transférer une information concernant ledit objet (18).

32. Système de surveillance d'un objet selon la revendication 30 ou 31, comprenant une pluralité de moyens formés de caméras (6, 8, 30, 34) pour surveiller des zones respectives, et adaptés pour communiquer avec un poste central (47) de manière à transférer une information concernant ledit objet (18).

33. Système de surveillance d'un objet selon la revendication 32, dans lequel ladite information concernant ledit objet (18) est acquise à l'aide d'au moins deux desdits moyens formés de caméras (6, 8, 30, 34) et ladite information peut être utilisée pour déterminer la durée, que met ledit objet à se déplacer entre au moins deux desdites zones.

34. Système de surveillance d'un objet selon la revendication 33, dans lequel ledit poste central (47) inclut des moyens de télécommande (53) pour commander lesdits moyens formés de caméras à partir dudit poste central.

35. Système de surveillance d'un objet selon la revendication 34, dans lequel ledit poste central (47) et ladite pluralité de moyens formés de caméras (6, 8, 30, 34) comprennent des dispositifs respectifs (55) de commande de télécommunication et communiquent en utilisant un réseau de télécommunication numérique (45).

36. Système de surveillance d'un objet selon la revendication 35, comprenant des moyens (49) pour archiver ladite information, et permettre un accès ultérieur à cette dernière.

37. Système de surveillance d'un objet selon la revendication 36, dans lequel ladite information inclut des images acquises dudit objet et les instants d'acquisition, et ledit poste central (47) inclut lesdits moyens de reconnaissance (51).

38. Système de surveillance d'un objet selon la revendication 36, dans lequel ladite information inclut ladite information d'identification et les instants d'acquisition d'images acquises dudit objet (18), une pluralité desdits moyens de reconnaissance (51) sont connectés respectivement à ladite pluralité de moyens formés de caméras (6, 8, 30, 34), au niveau des sites de ladite pluralité de moyens formés de caméras.

39. Système de surveillance d'un objet selon la revendication 37 ou 38, dans lequel lesdits moyens de reconnaissance (51) sont adaptés pour traiter ladite image acquise pour repérer des pixels représentatifs de pixels caractéristiques identifiant ledit objet (18).

40. Système de surveillance d'un objet selon l'une quelconque des revendications 1 à 39, dans lequel ledit objet (18) est un véhicule.

41. Système de surveillance d'un objet selon la revendication 40, considérée comme dépendante de la revendication 30, dans lequel lesdits moyens de reconnaissance comprennent des moyens pour repérer une plaque d'immatriculation dans ladite image et des moyens pour déterminer les caractères de la plaque d'immatriculation, lesdits caractères comprenant ladite information d'identification.

42. Système de surveillance d'un objet selon la revendication 41, considérée comme dépendante de la revendication 6, dans lequel ladite gamme prédéterminée de niveaux englobe les niveaux de pixel produits par des ombres dudit véhicule.

43. Système de surveillance d'un objet selon la revendication 42, considérée comme dépendante de la revendication 8, dans lequel lesdites régions non valables correspondent à des réflexions de phares, produites par lesdits véhicules ou des marquages routiers sur la chaussée à l'intérieur de ladite zone.

44. Système de surveillance d'un objet selon l'une quelconque des revendications 40 à 43, dans lequel ledit véhicule est un véhicule de grande taille, comme par exemple un autobus ou un camion.

45. Système de surveillance d'un objet selon l'une quelconque des revendications 1 à 44, dans lequel ledit objet (18) est un véhicule et dans lequel lesdits moyens formés de caméras (6, 8, 30, 34) sont adaptés pour surveiller ledit véhicule pour détecter une infraction à la loi et captent une image dudit véhicule audit instant prédéterminé en réponse à la détection de ladite infraction.

46. Système de surveillance d'un objet selon la revendication 45, comprenant des moyens de reconnaissance (51) pour traiter lesdites images pour obtenir une information identifiant ledit véhicule.

47. Système de surveillance selon la revendication 1, dans lequel les moyens formés de caméras (6, 8, 30, 34) produisent des images d'une zone et acquièrent une image d'un objet prédéterminé, incluant des moyens (30) de traitement d'images, comportant:

    des moyens (70, 72, 74, 76) pour soustraire une image d'arrière-plan desdites images de ladite zone pour produire des images de différence représentatives d'objets mobiles dans ladite zone;
    des moyens de segmentation (77, 78) pour traiter lesdites images de différence pour produire des images représentatives de régions correspondant à des parties desdits objets mobiles dans ladite zone;
    des moyens de classification (80) pour traiter lesdites images de régions, lesdits moyens de classification incluant les moyens (176) pour analyser la forme desdites régions et, sur la base de l'analyse, déterminer des régions valables et des régions non valables, des moyens de regroupement (176) pour produire, sur la base desdites régions valables, les regroupements correspondant à des objets respectifs parmi lesdits objets mobiles, et des moyens (176) pour classer lesdits regroupements par comparaison d'au moins une caractéristique desdits regroupements à des données de classification dudit système pour déterminer si l'un desdits regroupements correspond audit objet prédéterminé; et
    des moyens de suivi (180) pour réaliser le suivi de l'un desdits regroupements correspondant audit objet prédéterminé pour déterminer un instant d'acquisition d'images pour l'acquisition de ladite image dudit objet prédéterminé.

48. Système de surveillance d'un objet selon la revendication 47, dans lequel lesdits moyens (30) de traitement d'images filtrent lesdites images de différence pour ne pas prendre en compte des pixels dans une gamme prédéterminée d'intensités.

49. Système de surveillance d'un objet selon la revendication 48, dans lequel lesdites parties d'objets mobiles correspondent à au moins un niveau de lumière prédéterminé reçu au milieu desdits moyens formés de caméras (6, 8, 30, 34).

50. Système de surveillance d'un objet selon la revendication 49, dans lequel lesdits moyens de classification (80) étendent lesdites régions valables pour déterminer si lesdites régions doivent être combinées pour former lesdits regroupements.

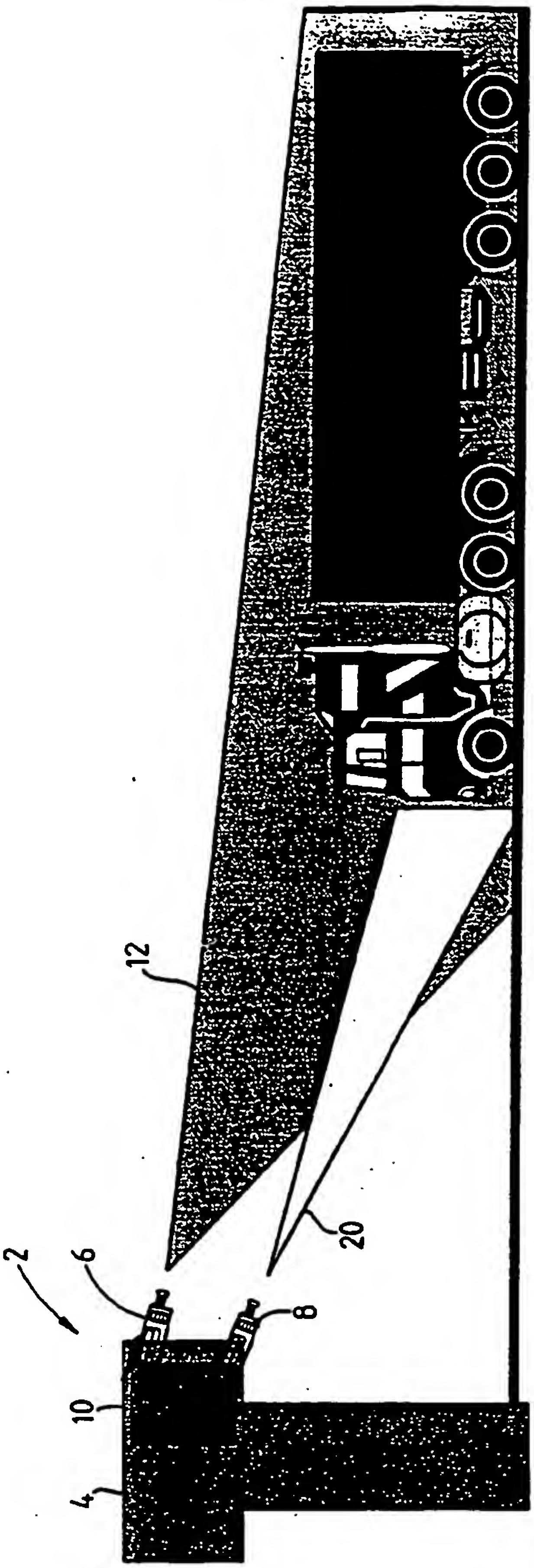

FIG 1

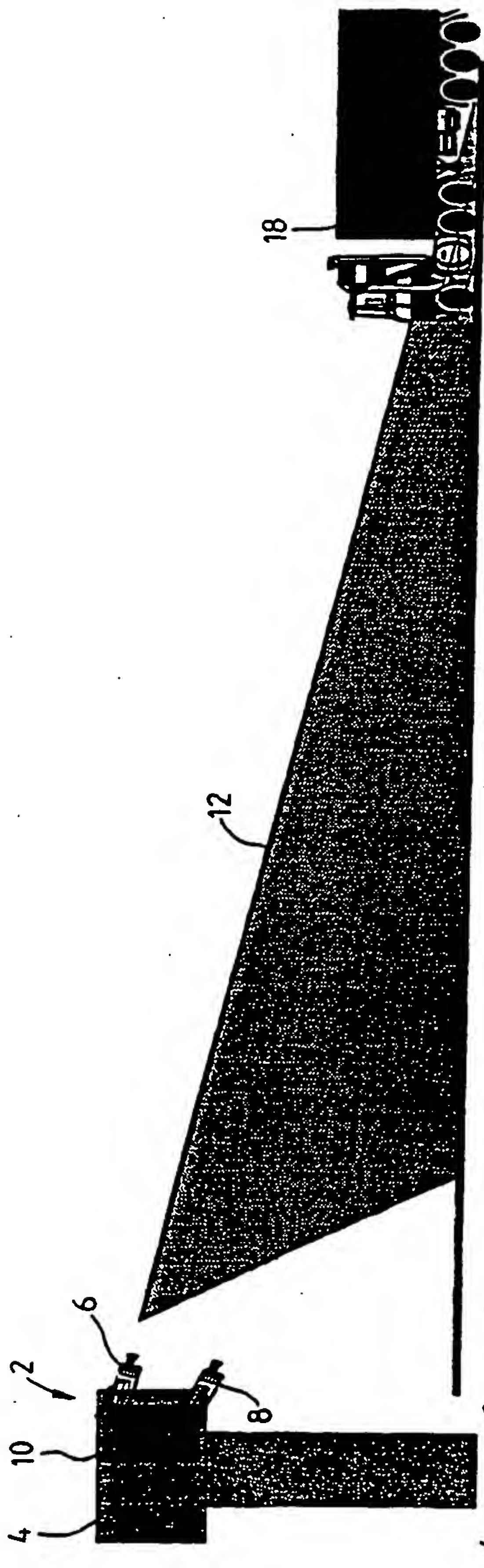

FIG 2

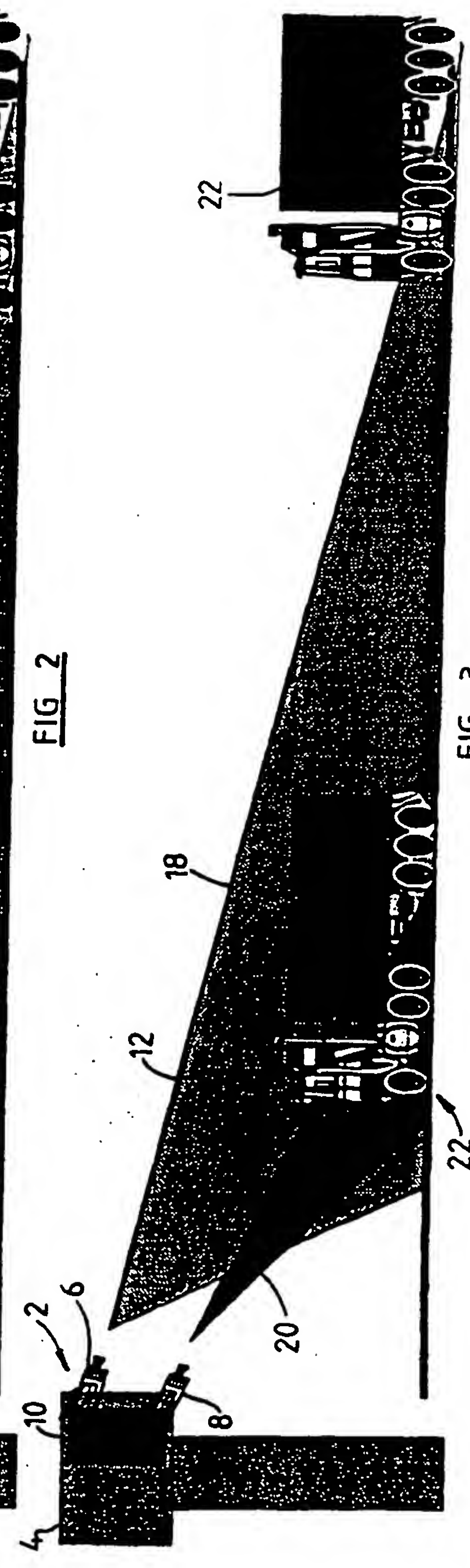

FIG 3

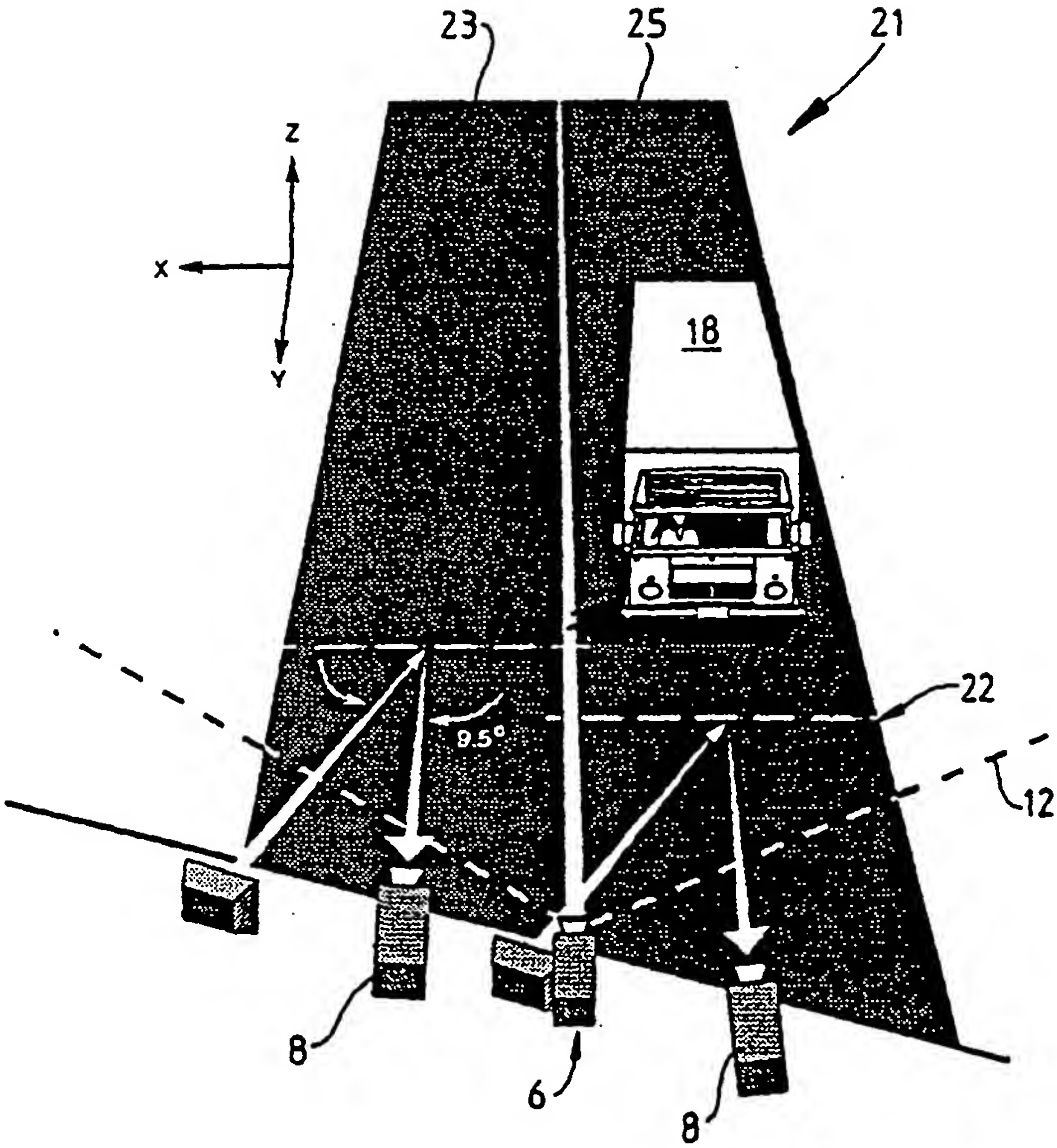

FIG 4

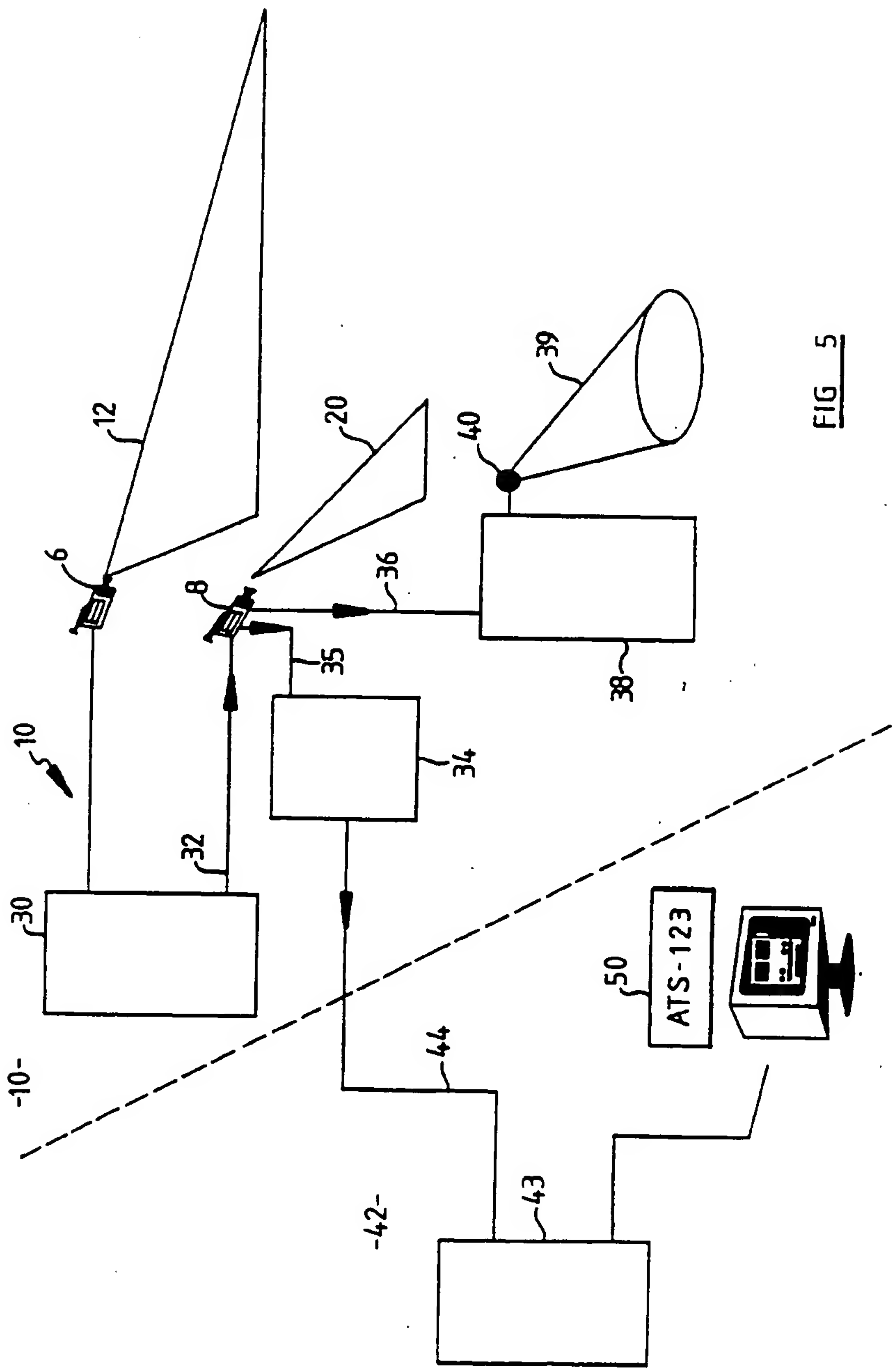

FIG 5

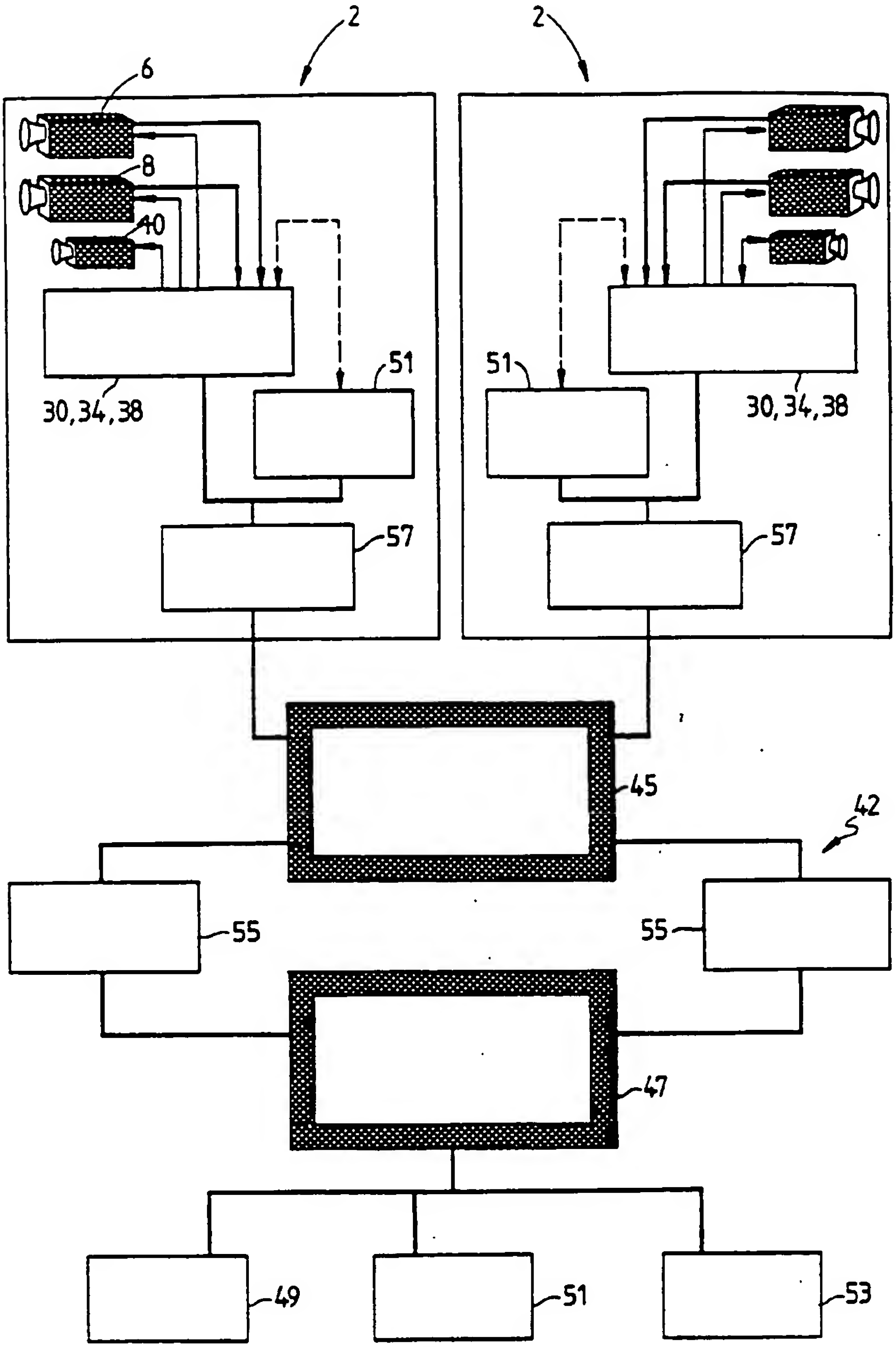

FIG 6

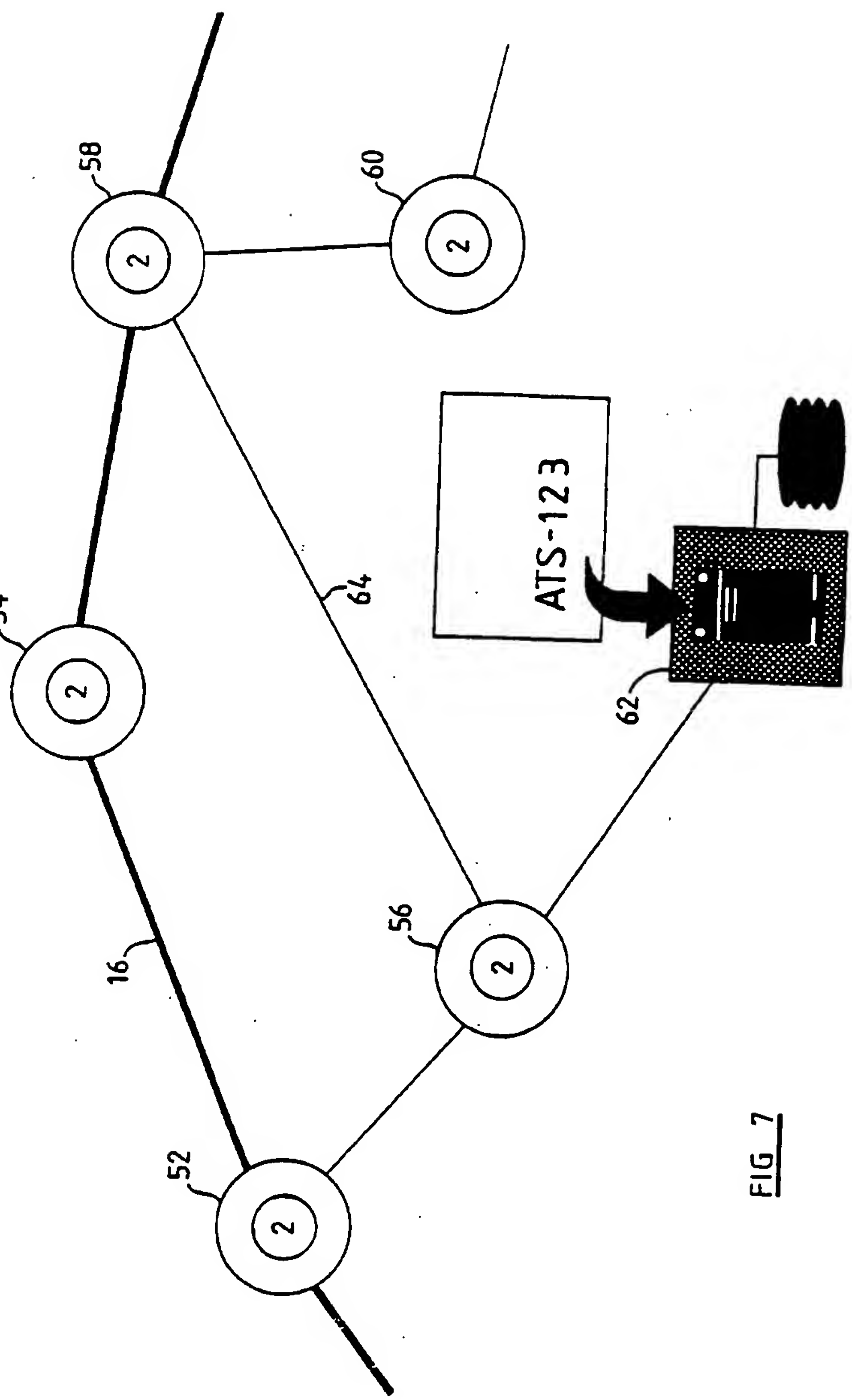

FIG 7

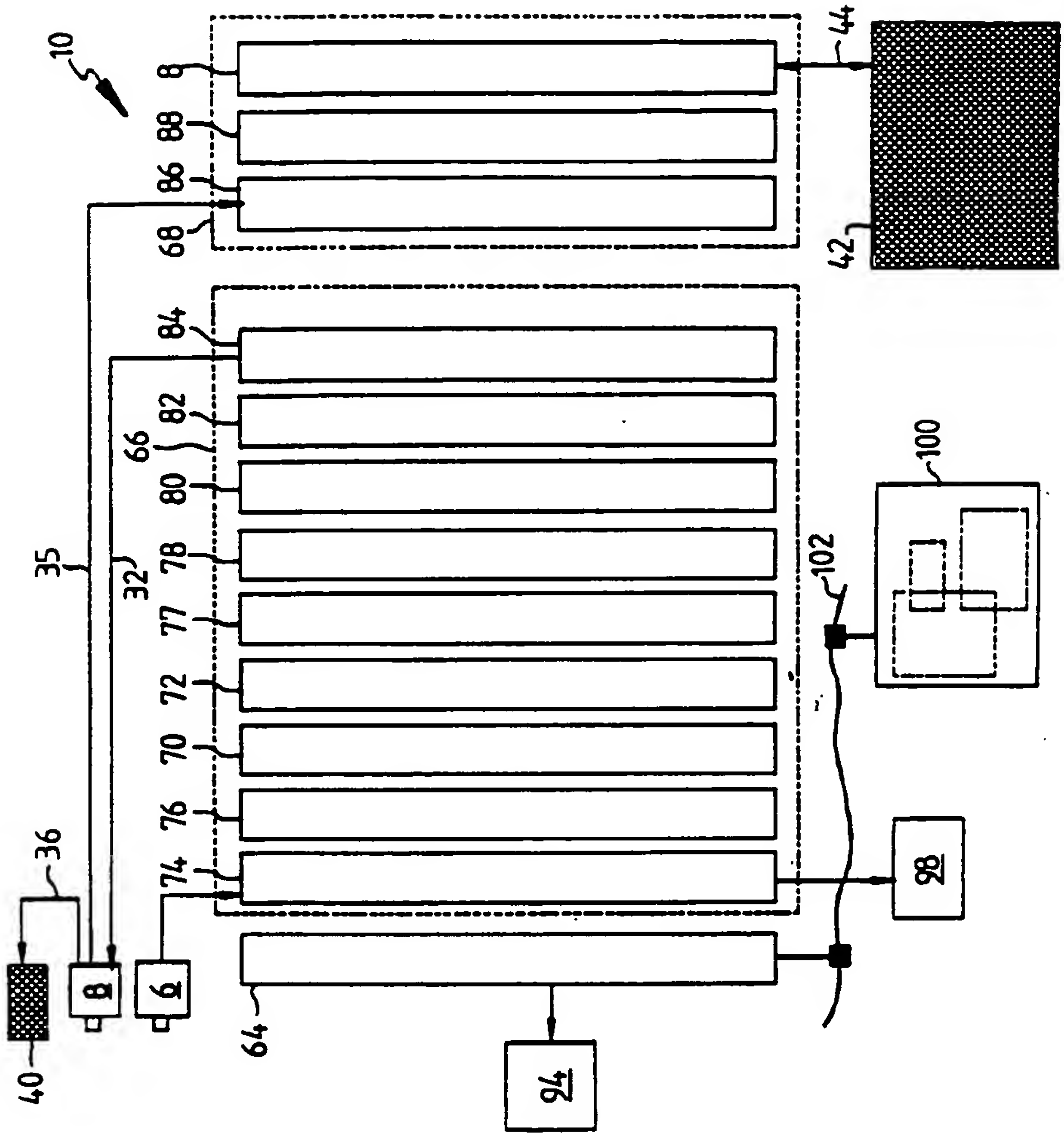
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FIG 8

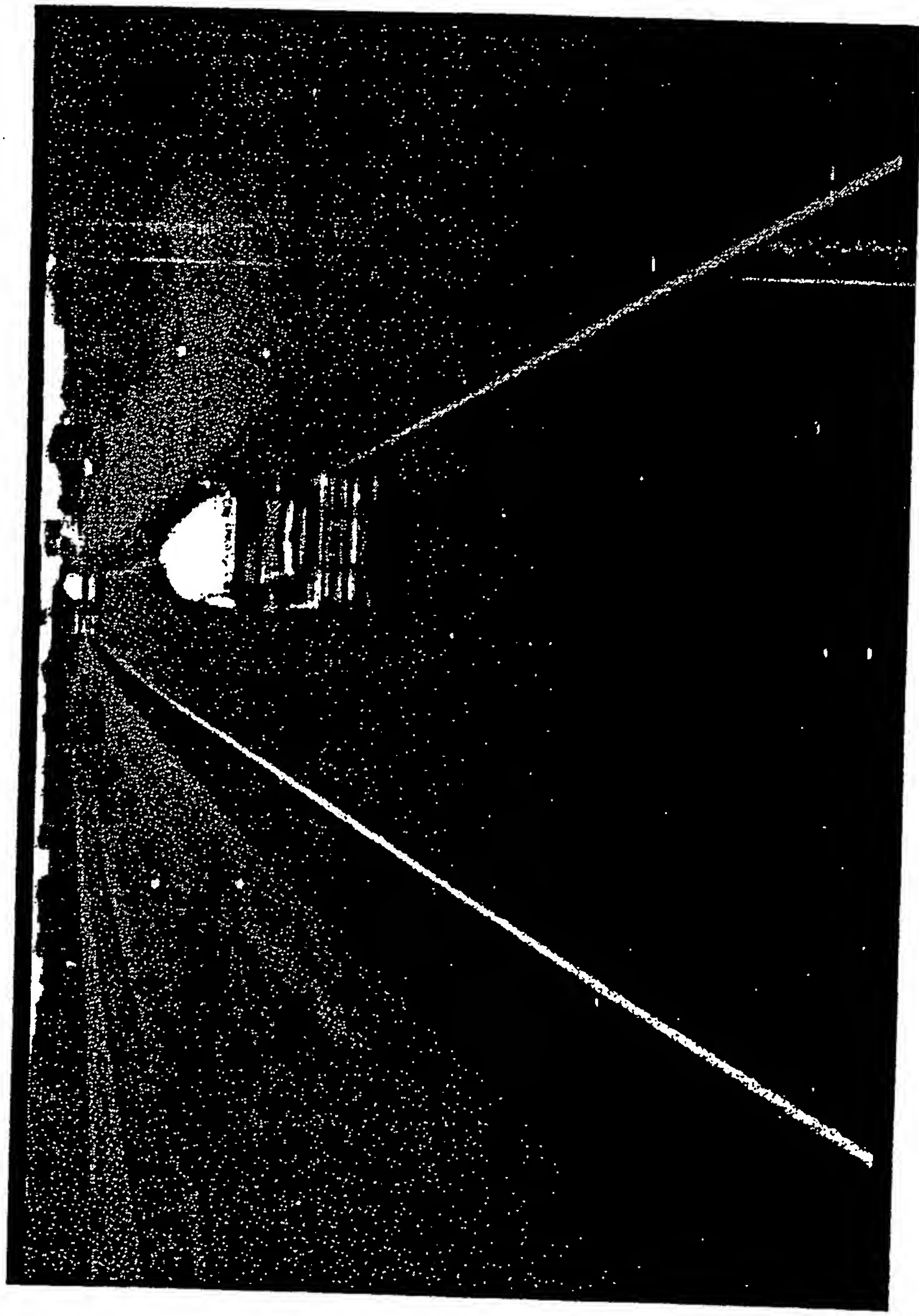


FIG. 9

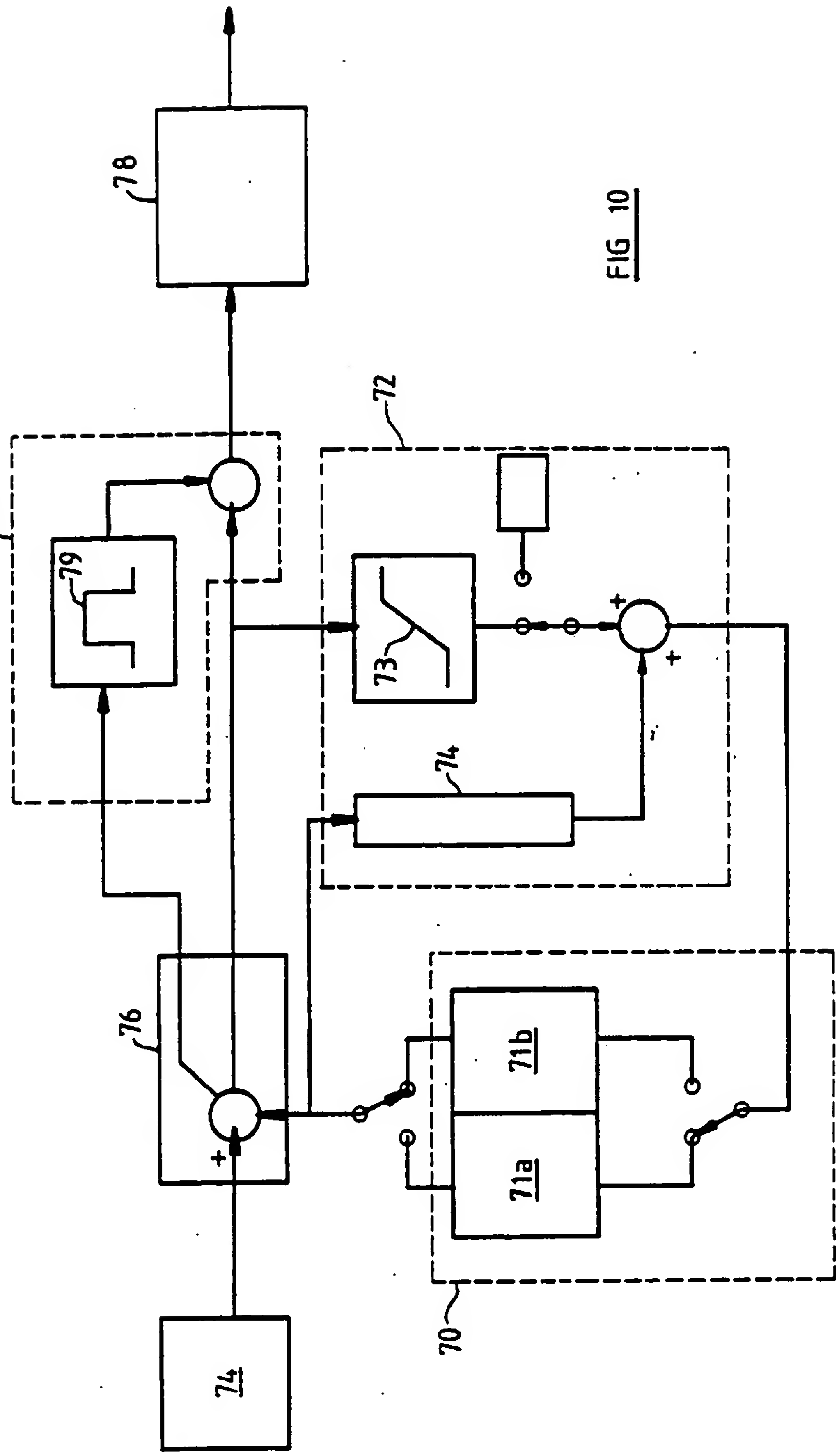


FIG 10

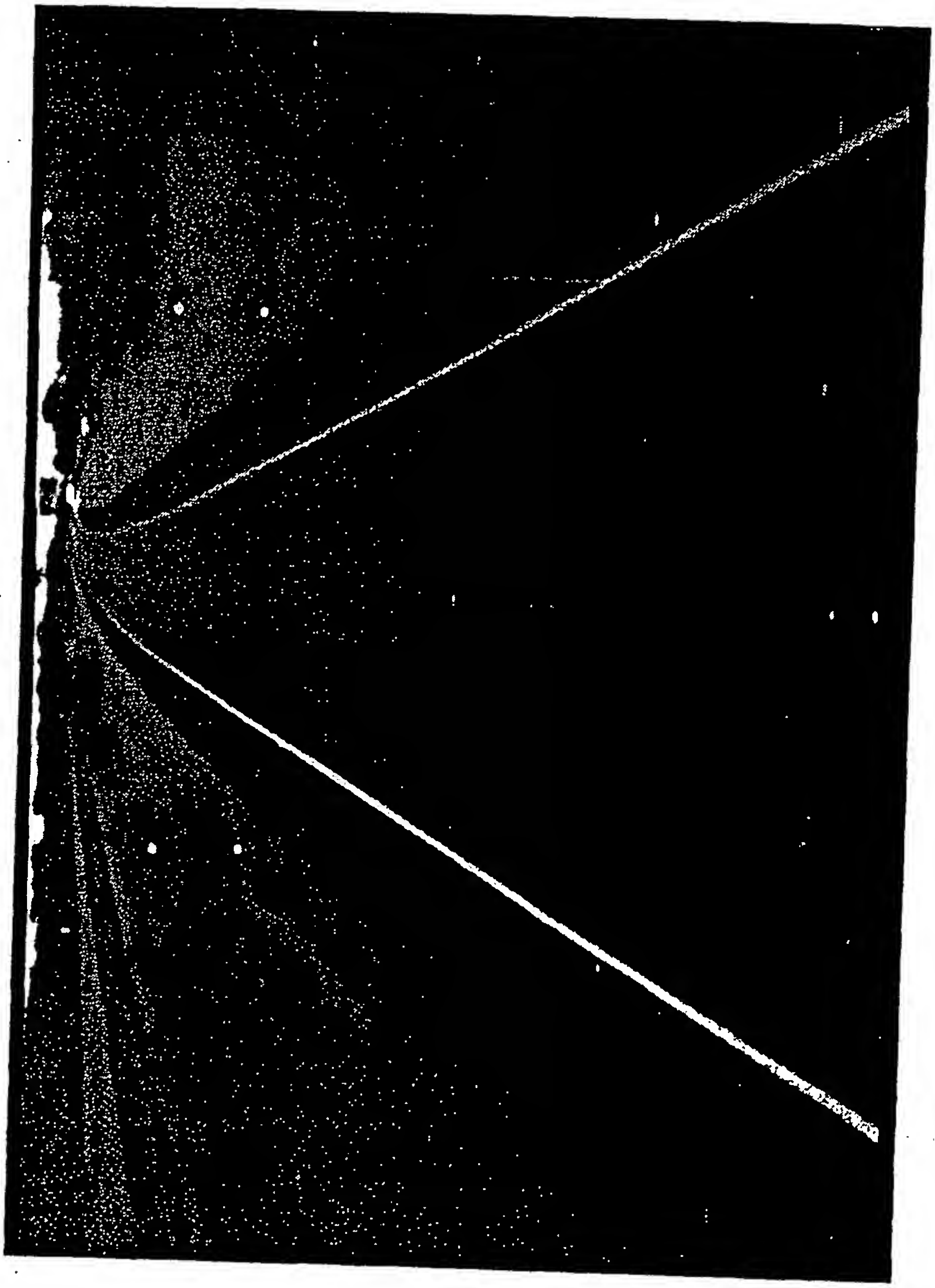


FIG. 11

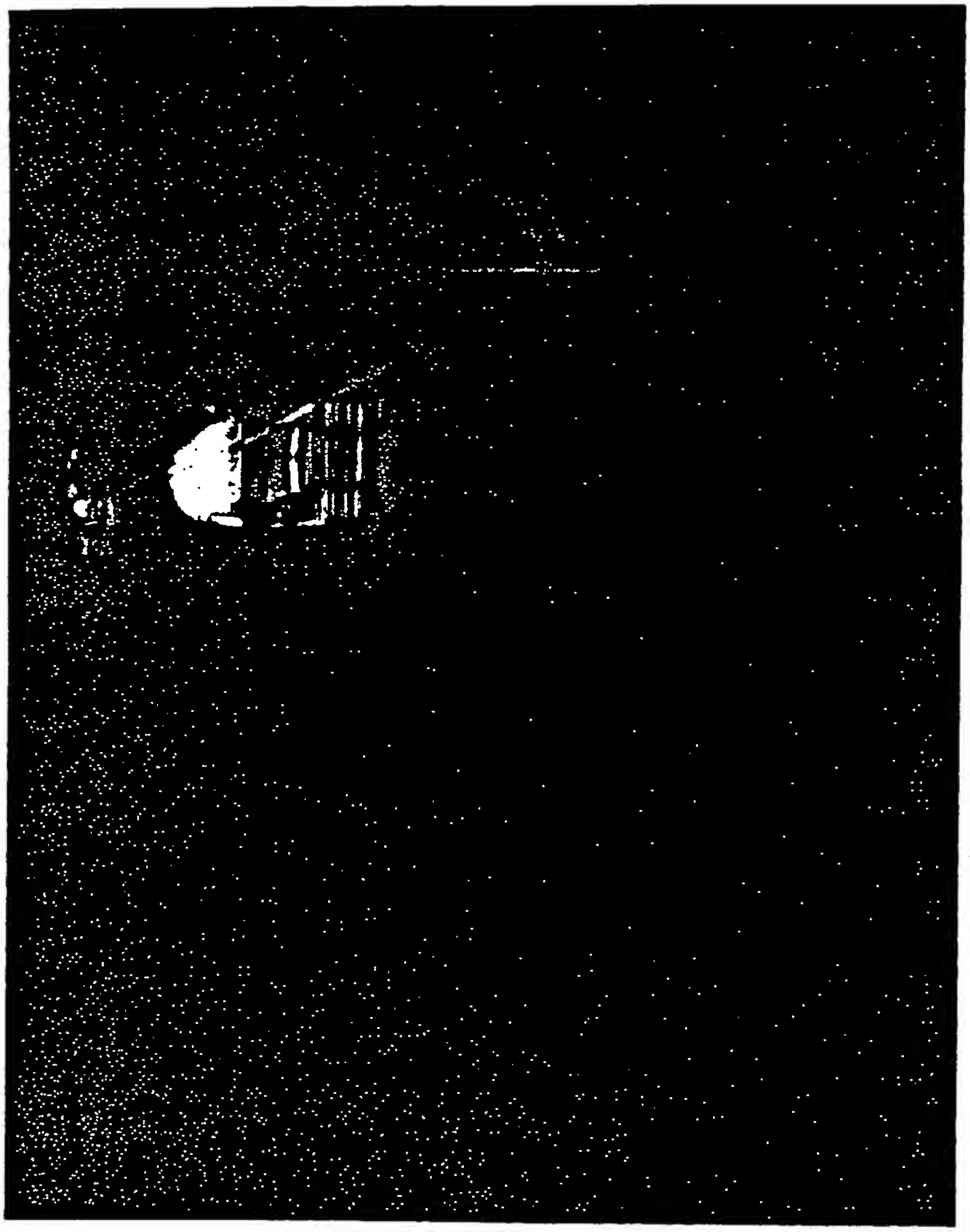


FIG. 12

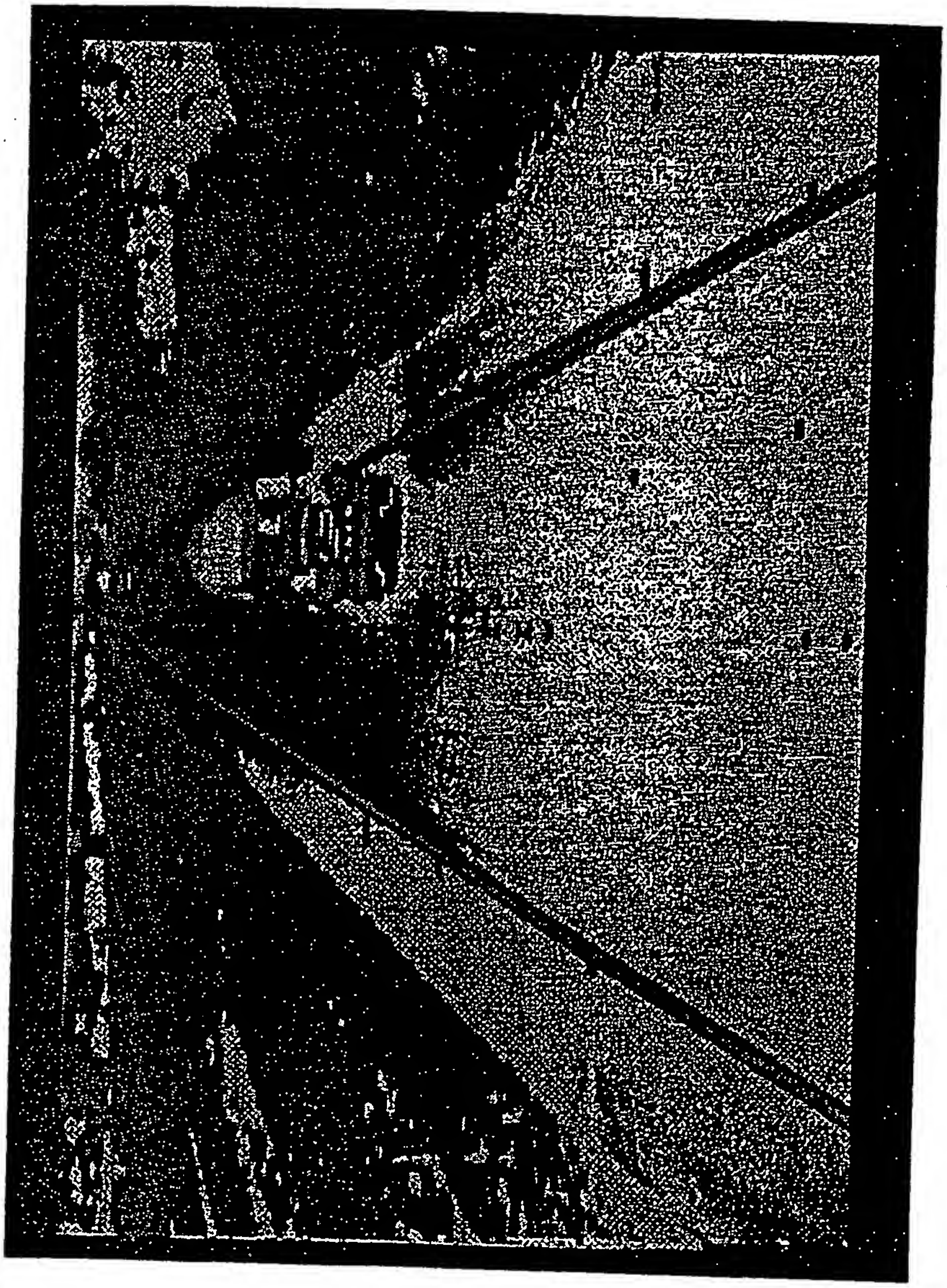


FIG. 13

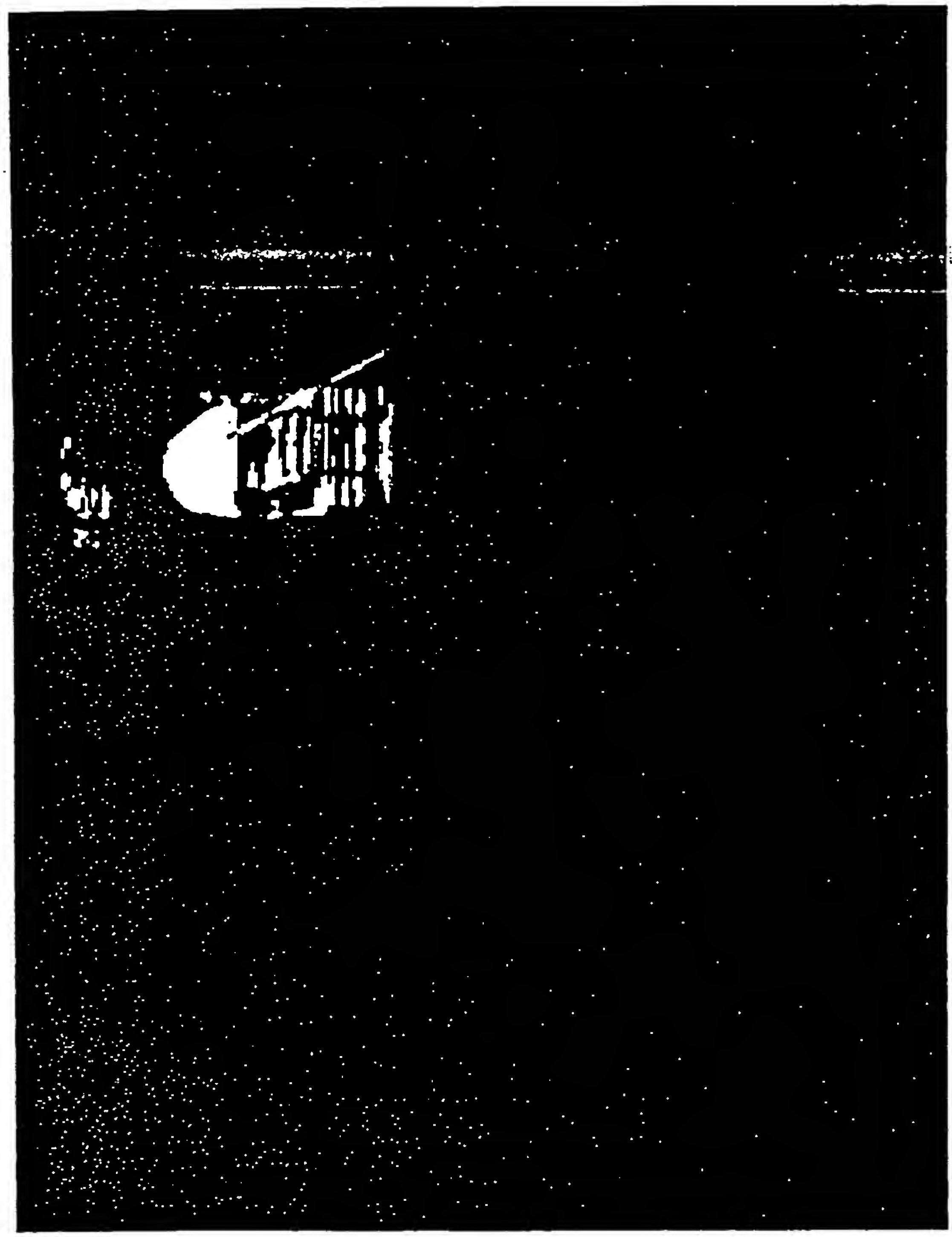


FIG. 14

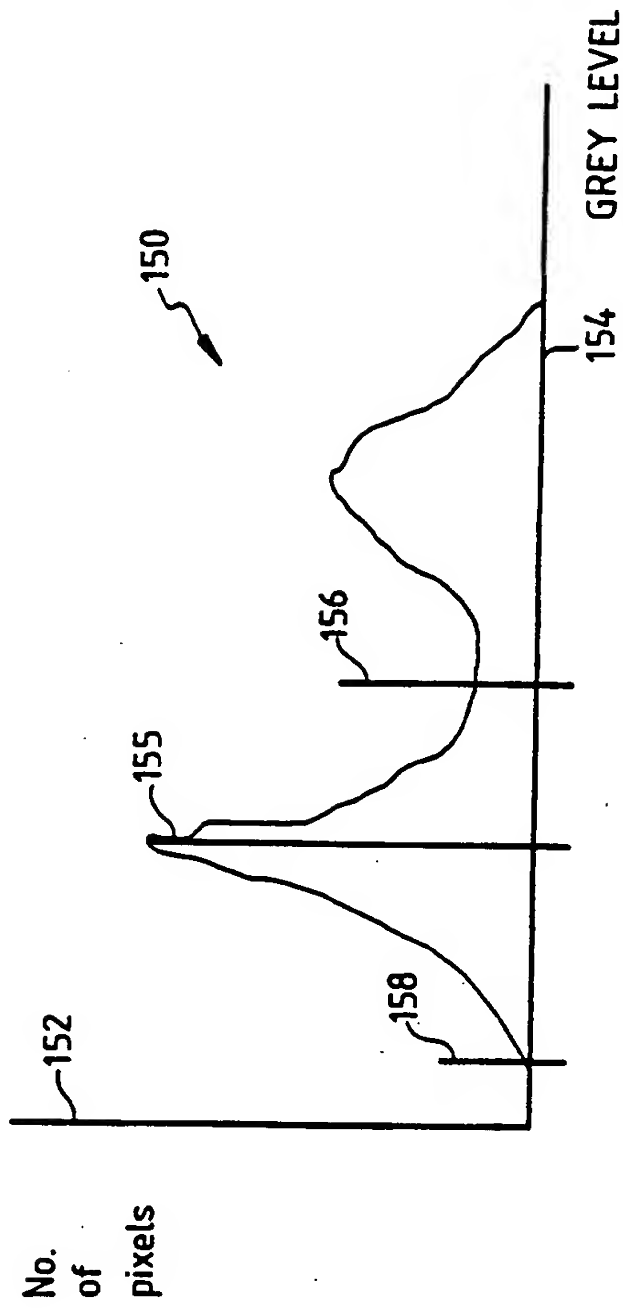


FIG 15

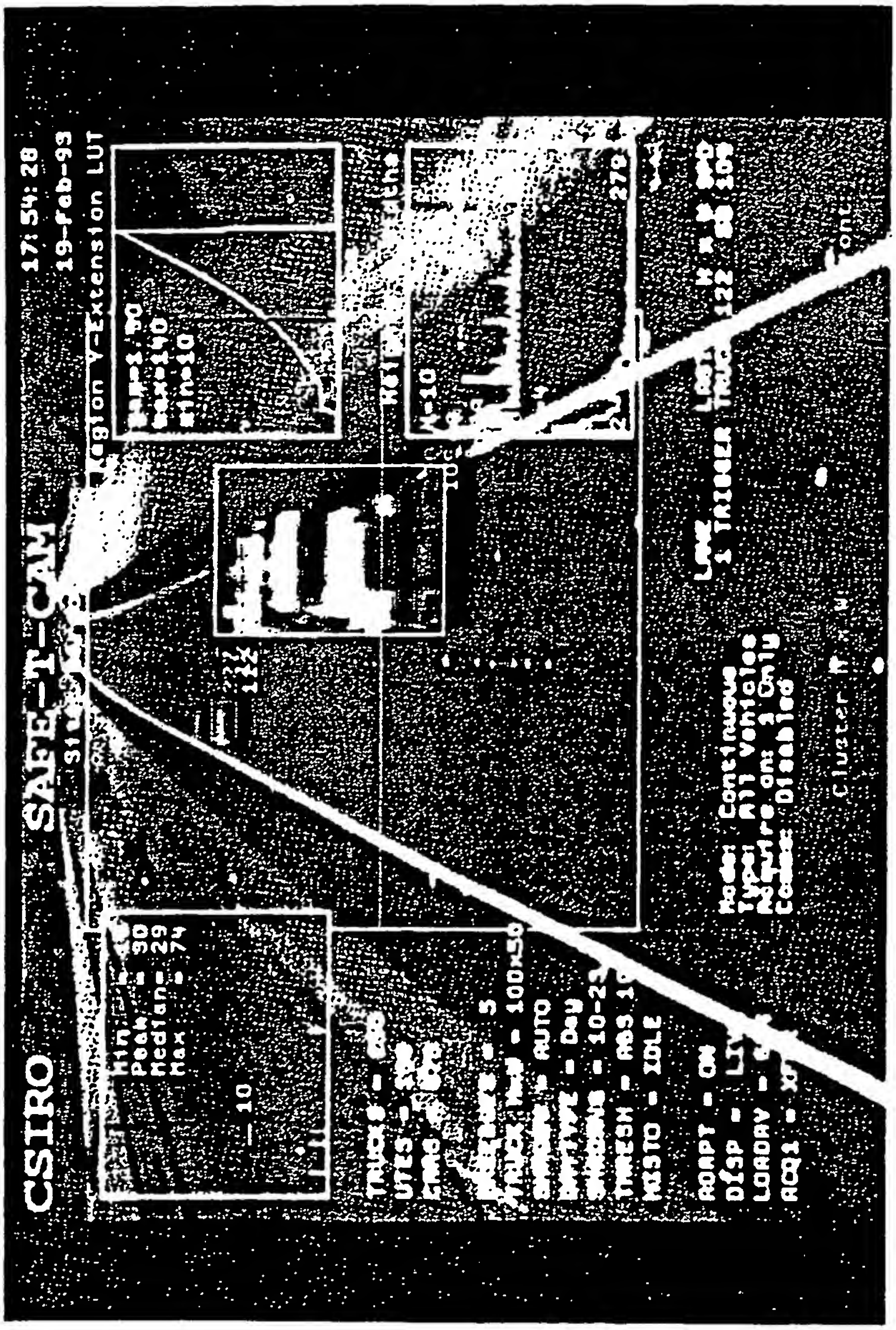
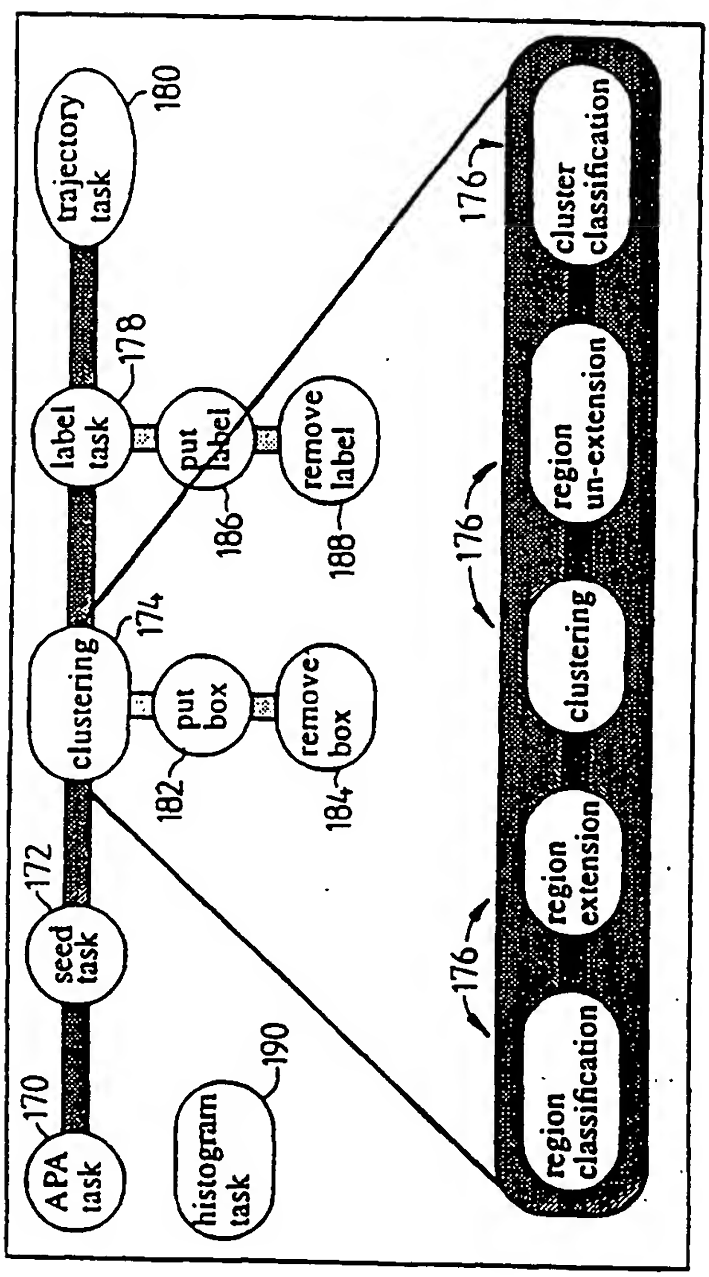


FIG. 16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seed task
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clustering
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label task
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trajectory task
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histogram task
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put box
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remove box
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put label
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remove label
188
176
region classification
region extension
clustering
region un-extension
cluster classification

FIG 17

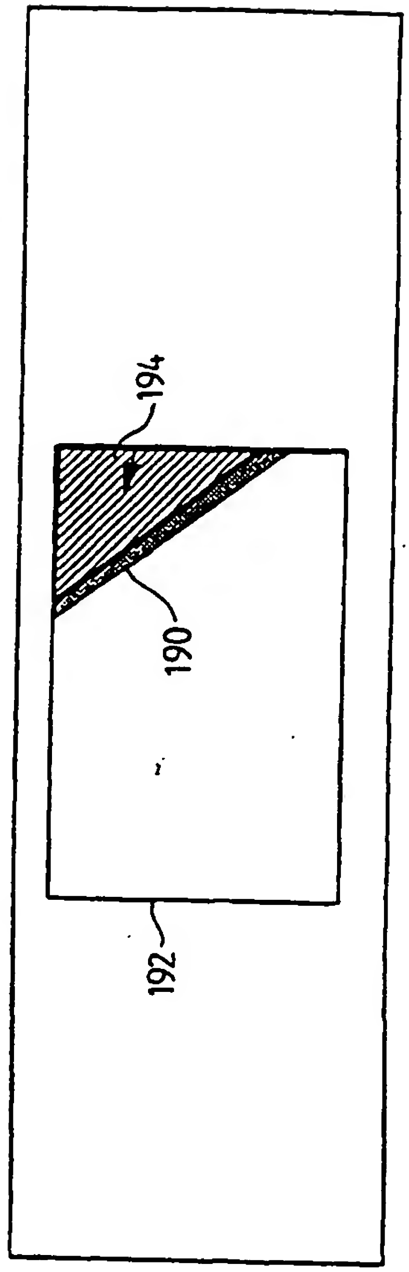
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FIG 18

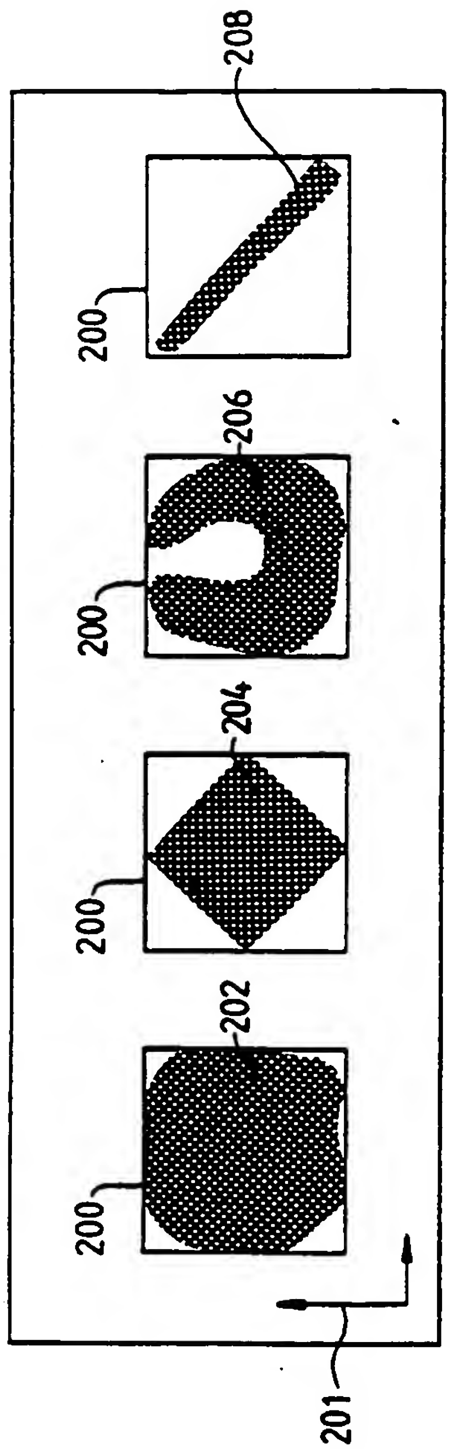


FIG 19

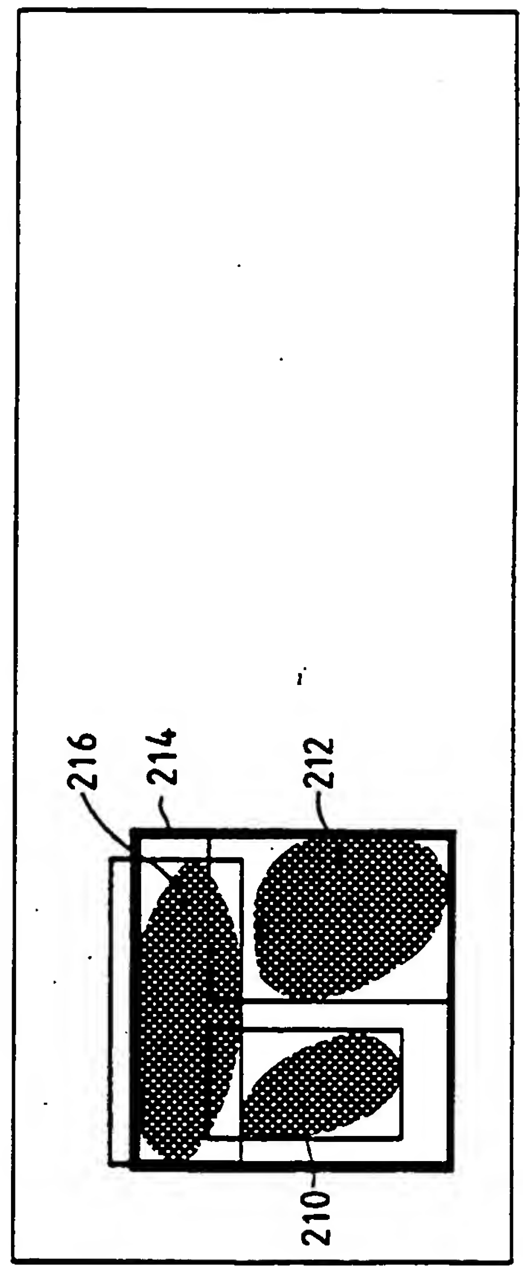


FIG 20

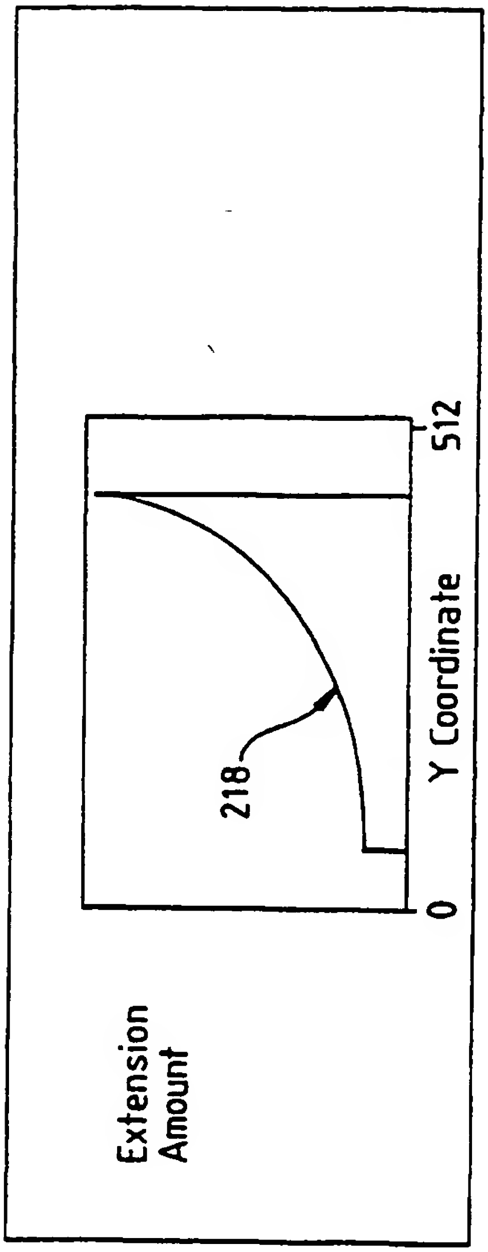


FIG 21

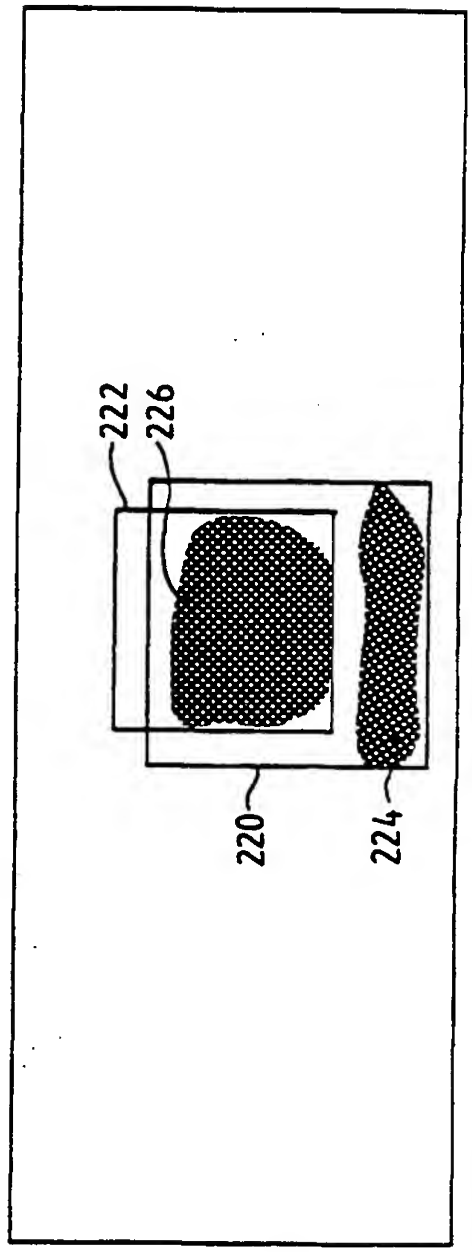
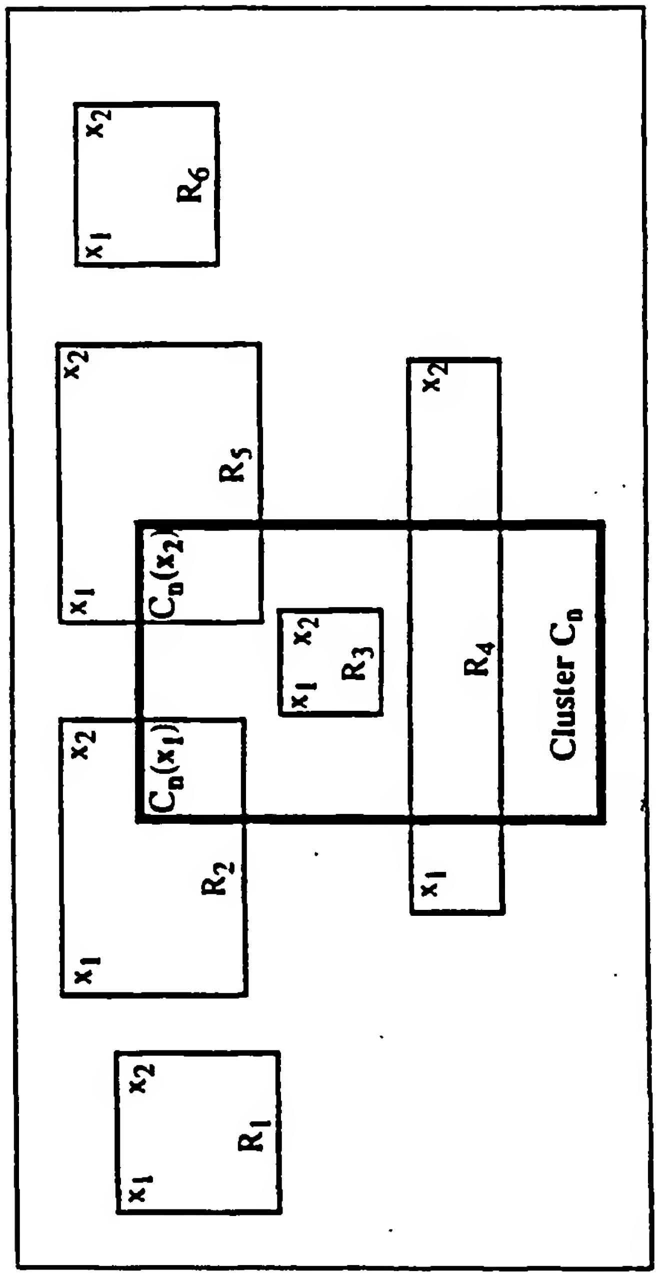


FIG 22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R4
x1
Cn(x2)
x2
R3
x1
Cn(x1)
Cluster Cn
x2
R2
x1
x2
R1
x1

FIG 23

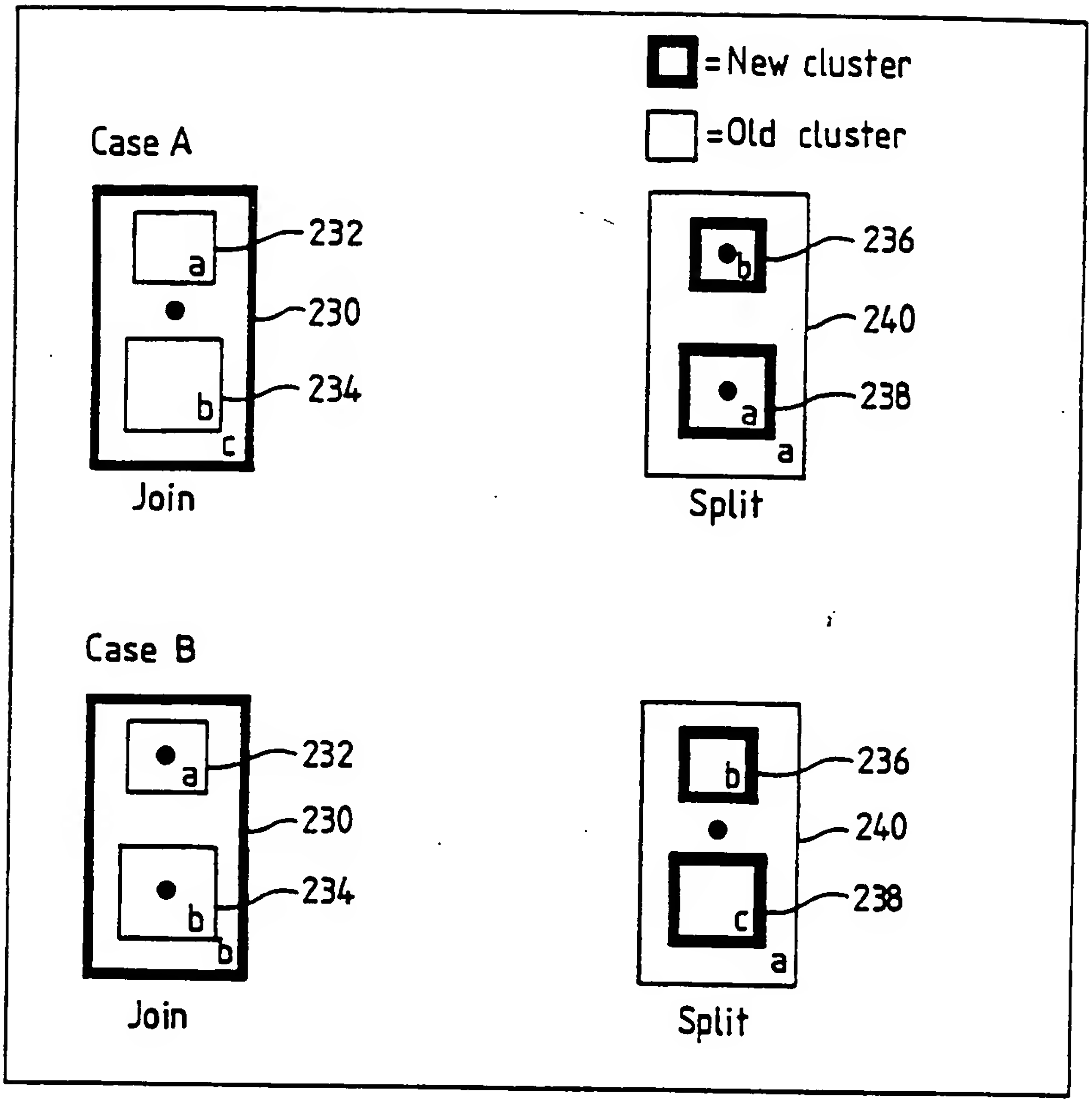

=New cluster
=Old cluster
Case A
232
a
230
234
b
c
Join
236
b
240
238
a
a
Split
Case B
232
a
230
234
b
b
Join
236
b
240
238
c
a
Split

FIG 24

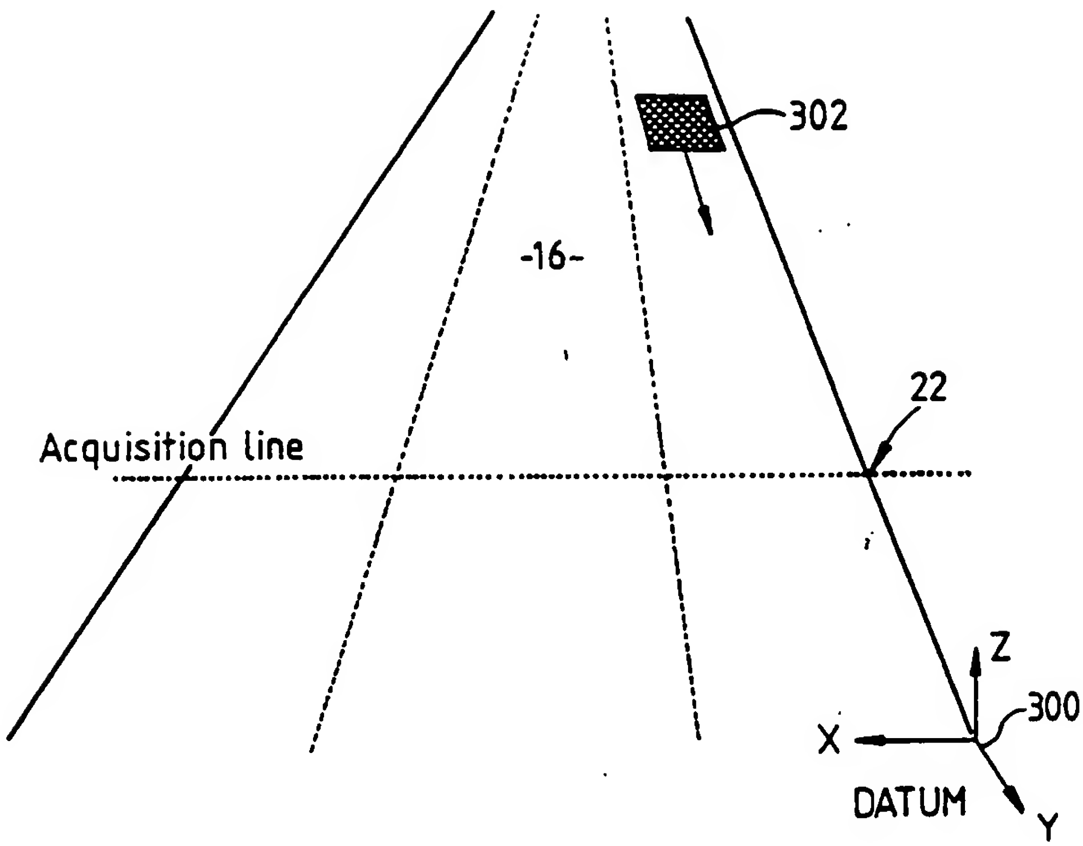


FIG 25

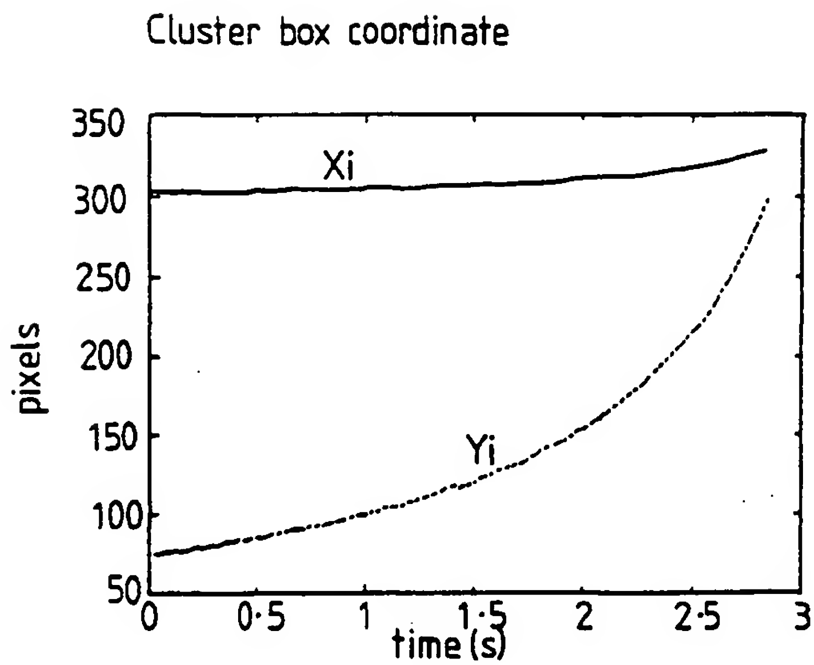

Cluster box coordinate
350
300
250
200
150
100
50
pixels
Xi
Yi
0
0·5
1
1·5
2
2·5
3
time (s)

FIG 26

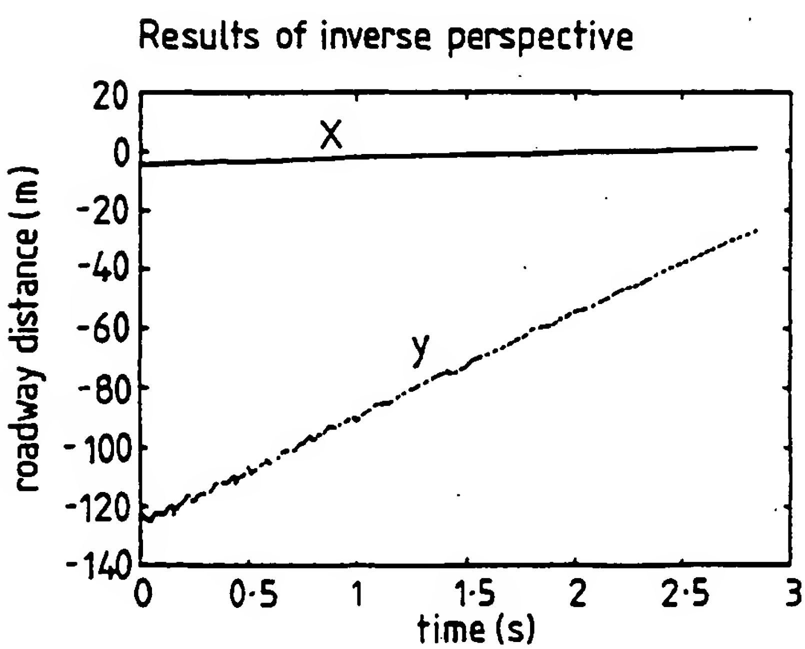
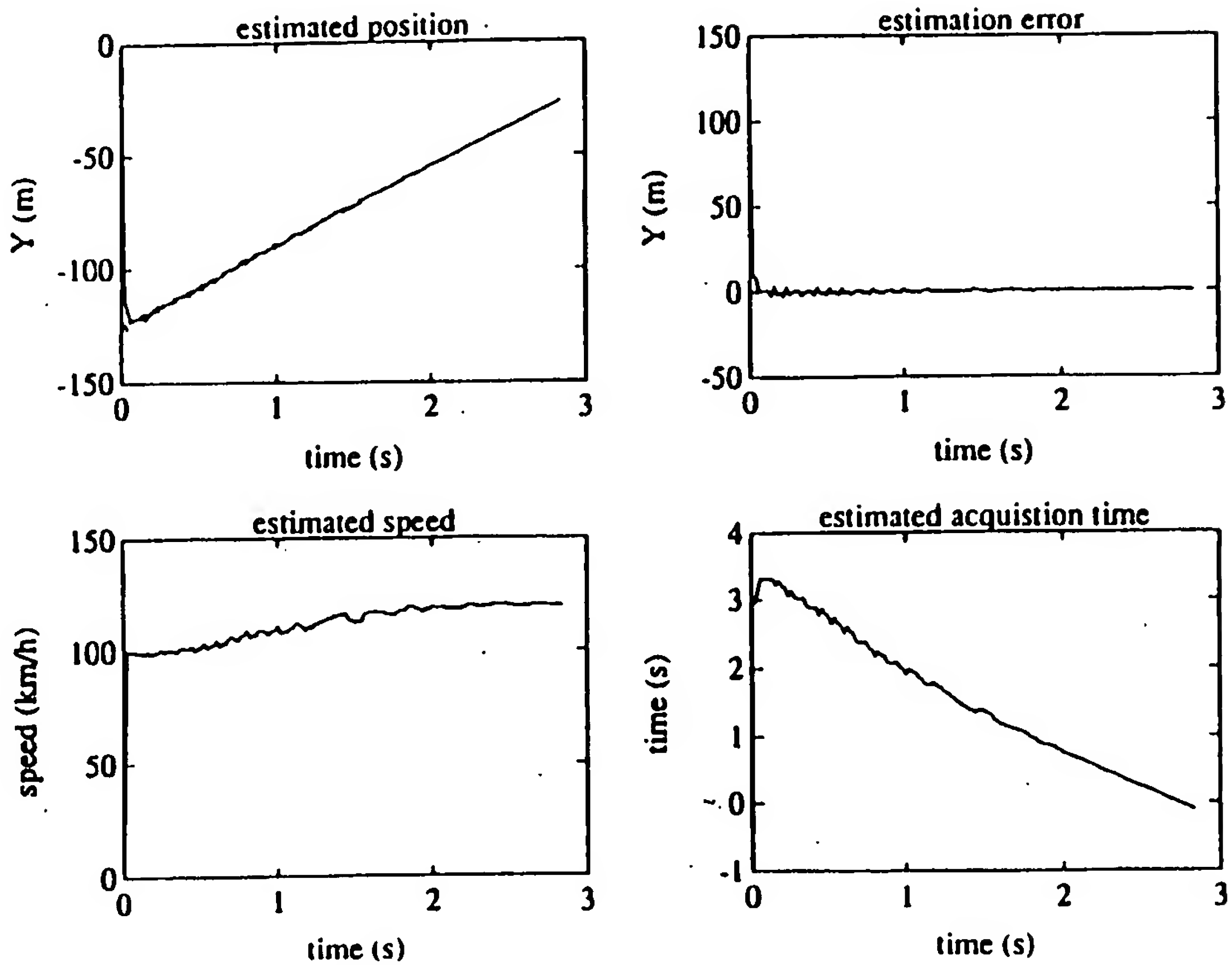

Results of inverse perspective
20
0
-20
-40
-60
-80
-100
-120
-140
roadway distance (m)
X
y
0
0·5
1
1·5
2
2·5
3
time (s)

FIG 27



estimated position
Y (m)
0
-50
-100
-150
0
1
2
3
time (s)
estimation error
Y (m)
150
100
50
0
-50
0
1
2
3
time (s)
estimated speed
speed (km/h)
150
100
50
0
0
1
2
3
time (s)
estimated acquistion time
time (s)
4
3
2
1
0
-1
0
1
2
3
time (s)

FIG 28

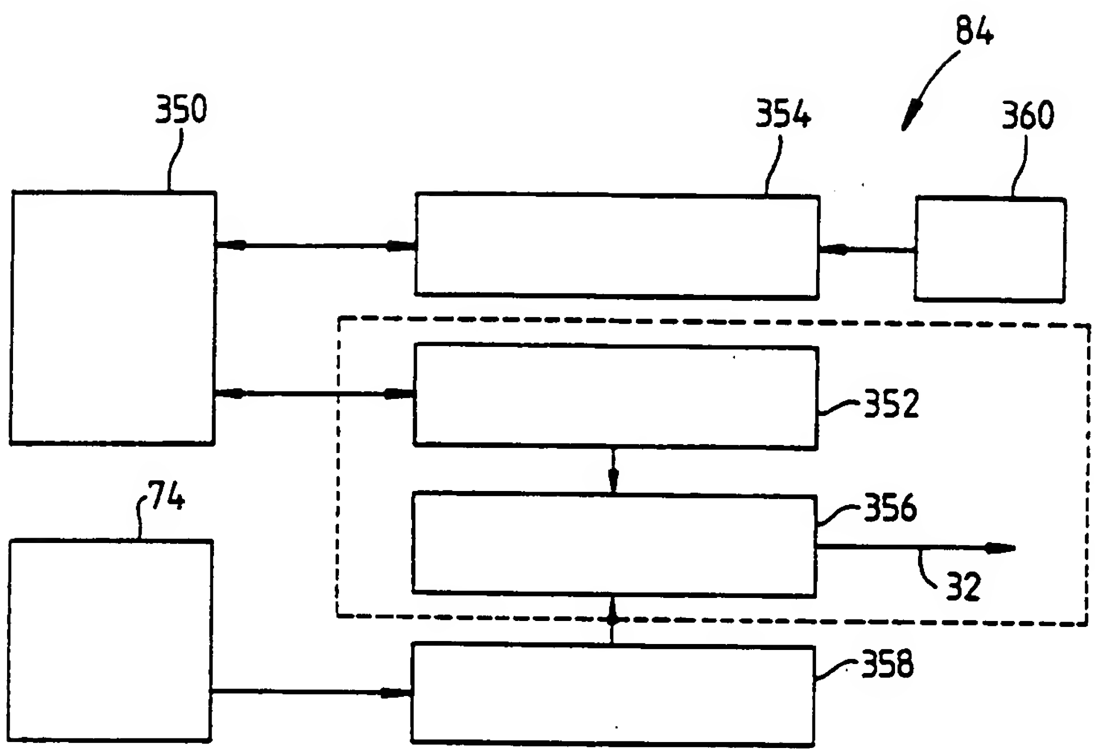
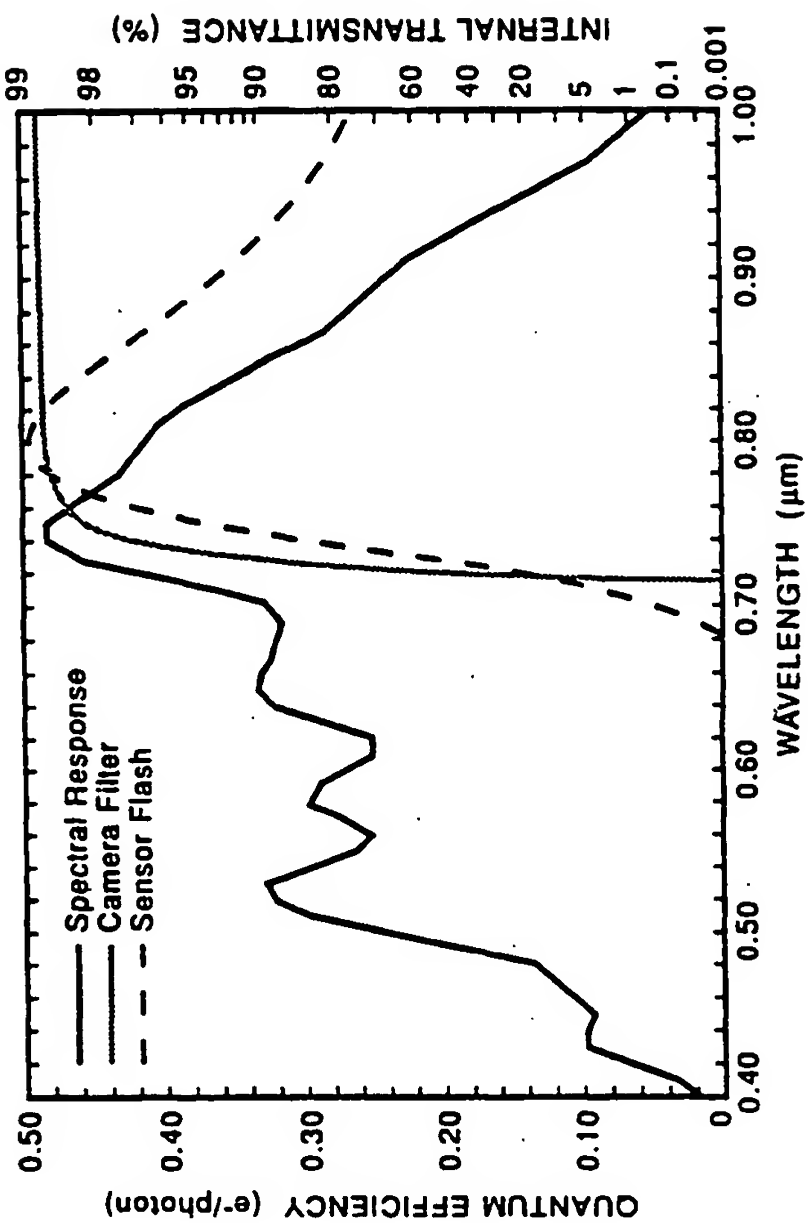


FIG 29



INTERNAL TRANSMITTANCE (%)
99
98
95
90
80
60
40
20
5
1
0.1
0.001
Spectral Response
Camera Filter
Sensor Flash
QUANTUM EFFICIENCY (e-/photon)
0.50
0.40
0.30
0.20
0.10
0
0.40
0.50
0.60
0.70
0.80
0.90
1.00
WAVELENGTH (µm)

FIG 30

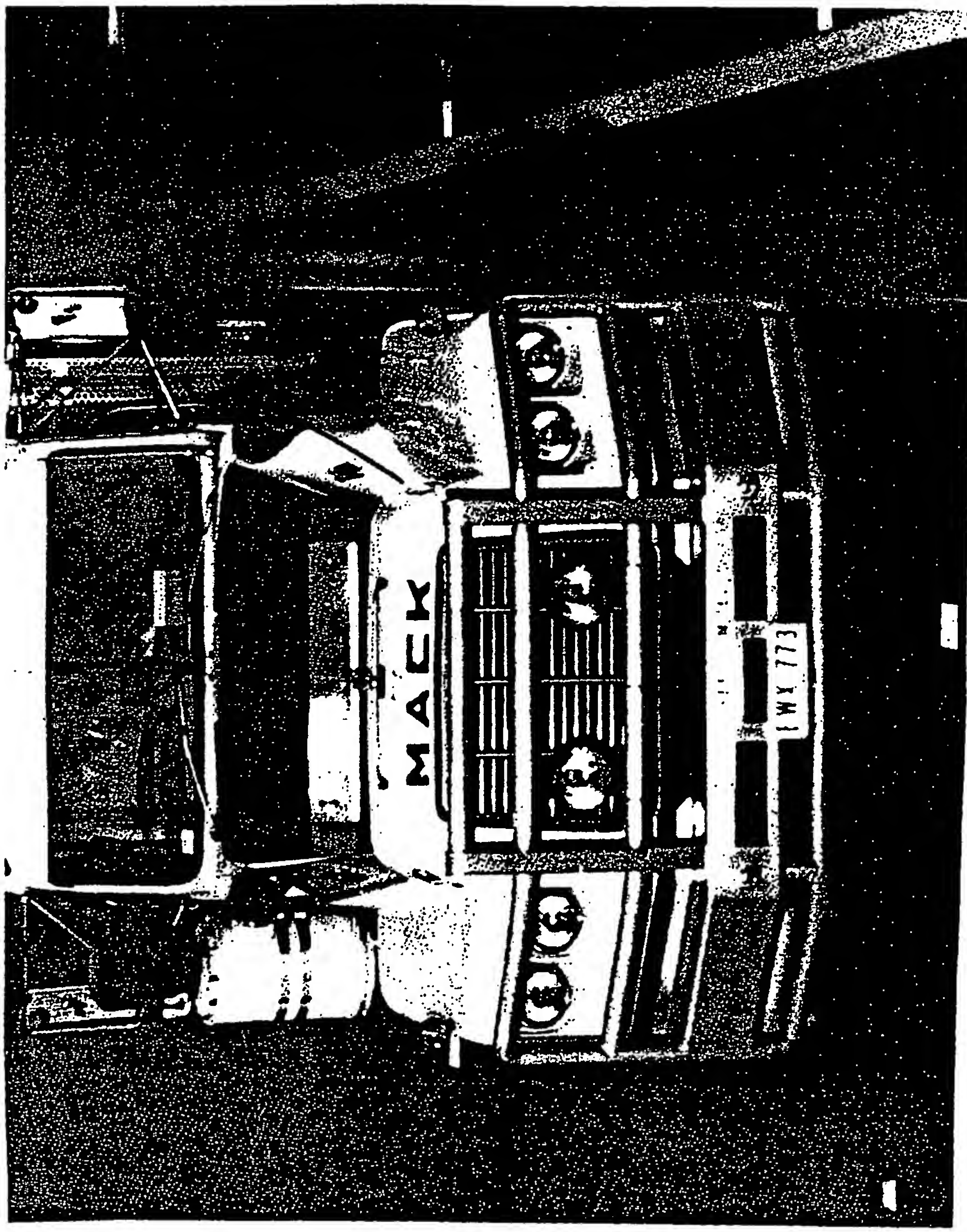


FIG. 31

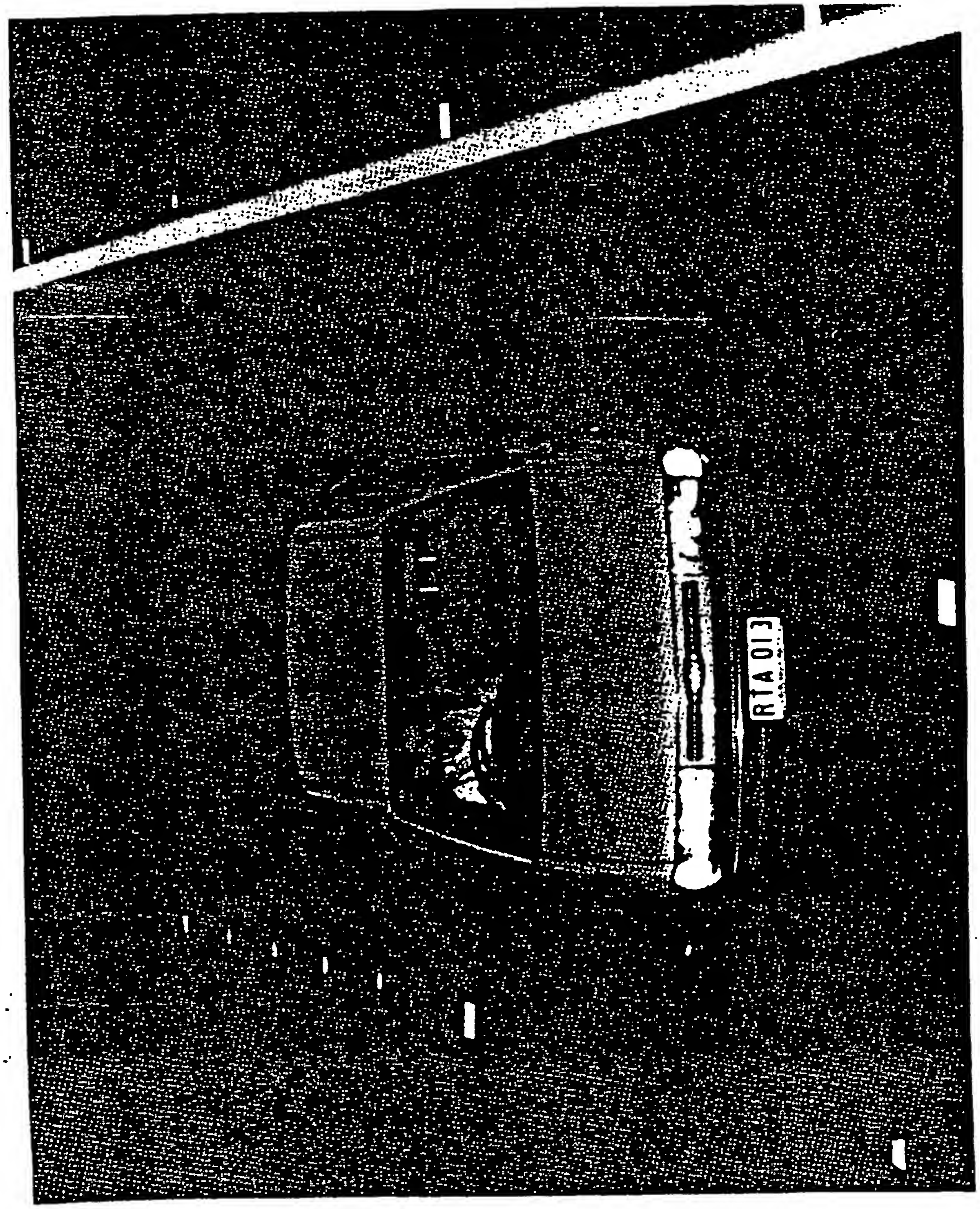


FIG. 32

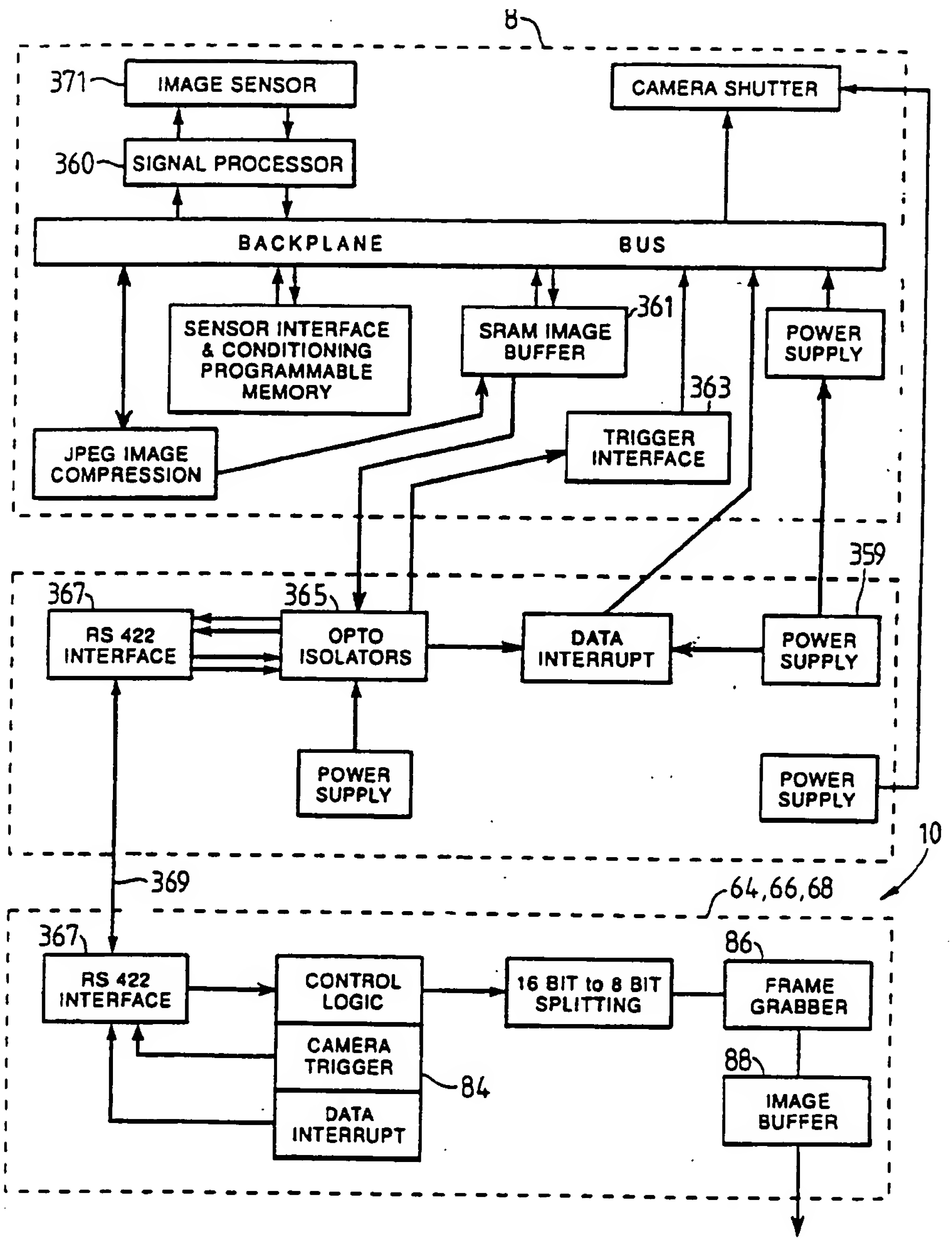

8
371
IMAGE SENSOR
CAMERA SHUTTER
360
SIGNAL PROCESSOR
BACKPLANE BUS
SENSOR INTERFACE & CONDITIONING PROGRAMMABLE MEMORY
SRAM IMAGE BUFFER
361
POWER SUPPLY
363
JPEG IMAGE COMPRESSION
TRIGGER INTERFACE
359
367
365
RS 422 INTERFACE
OPTO ISOLATORS
DATA INTERRUPT
POWER SUPPLY
POWER SUPPLY
POWER SUPPLY
10
369
64,66,68
367
86
RS 422 INTERFACE
CONTROL LOGIC
16 BIT to 8 BIT SPLITTING
FRAME GRABBER
CAMERA TRIGGER
84
88
DATA INTERRUPT
IMAGE BUFFER

FIG 33

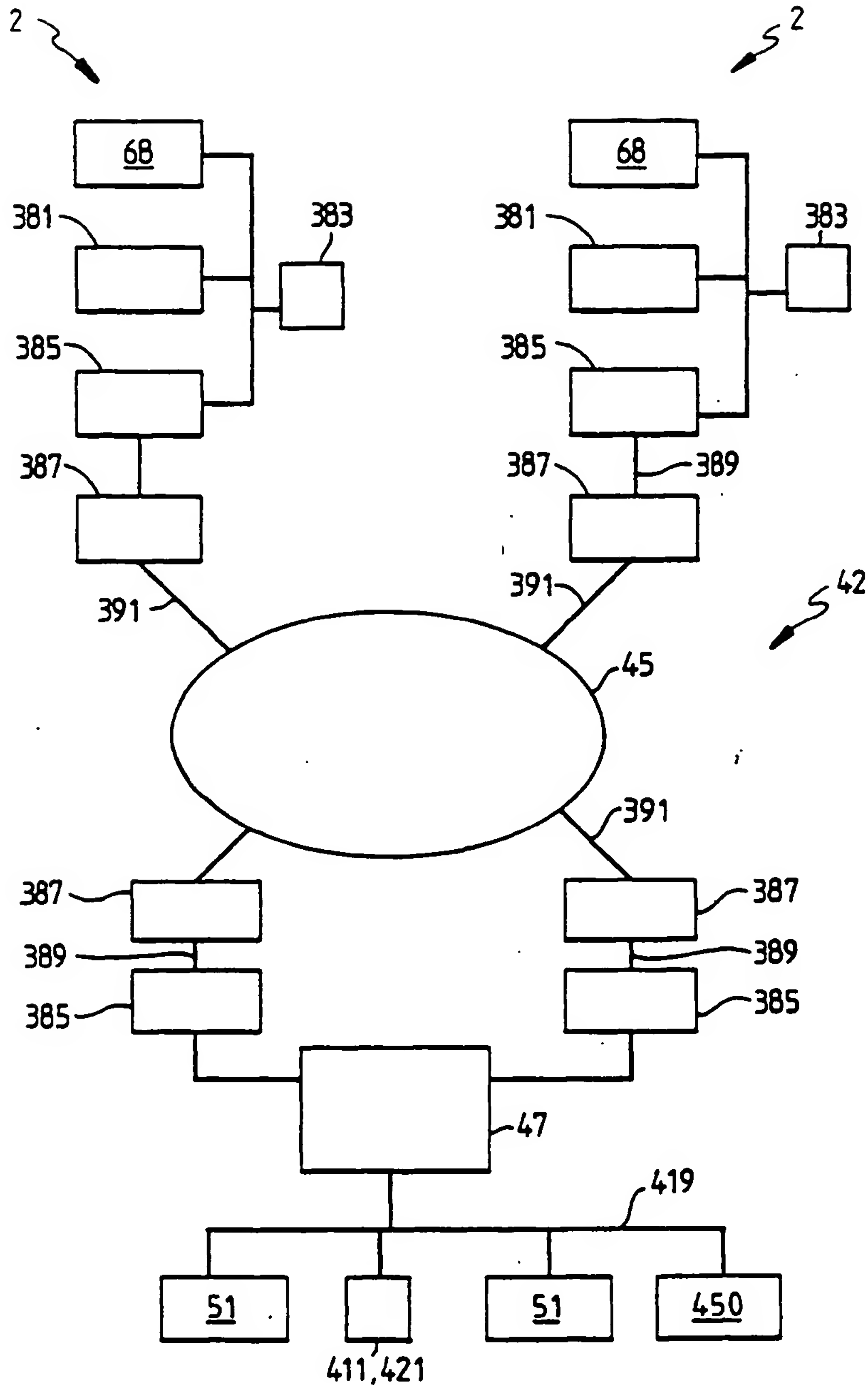
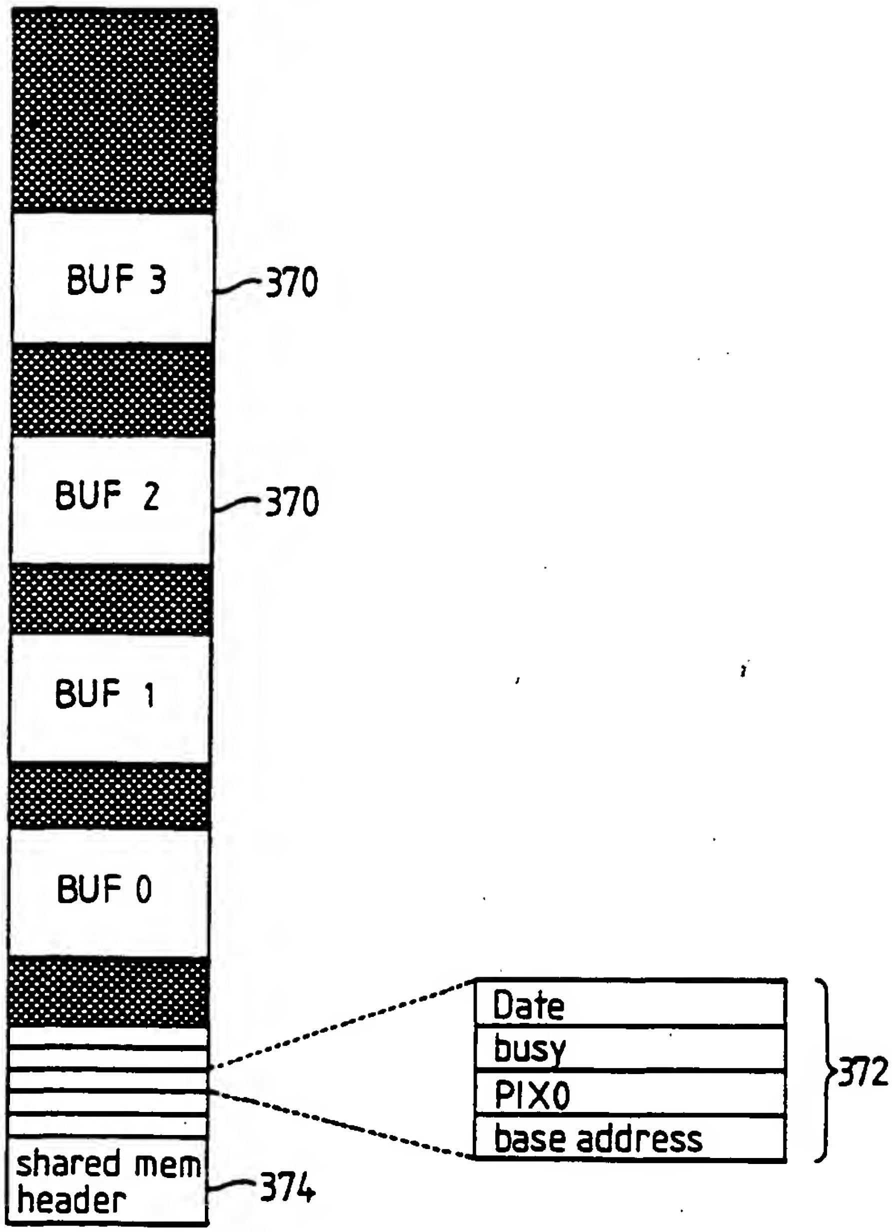

2
2
68
68
381
383
381
383
385
385
387
387
389
391
391
42
45
391
387
387
389
389
385
385
47
419
51
51
450
411,421

FIG 34



BUF 3
370
BUF 2
370
BUF 1
BUF 0
Date
busy
PIX0
base address
372
shared mem header
374

FIG 35

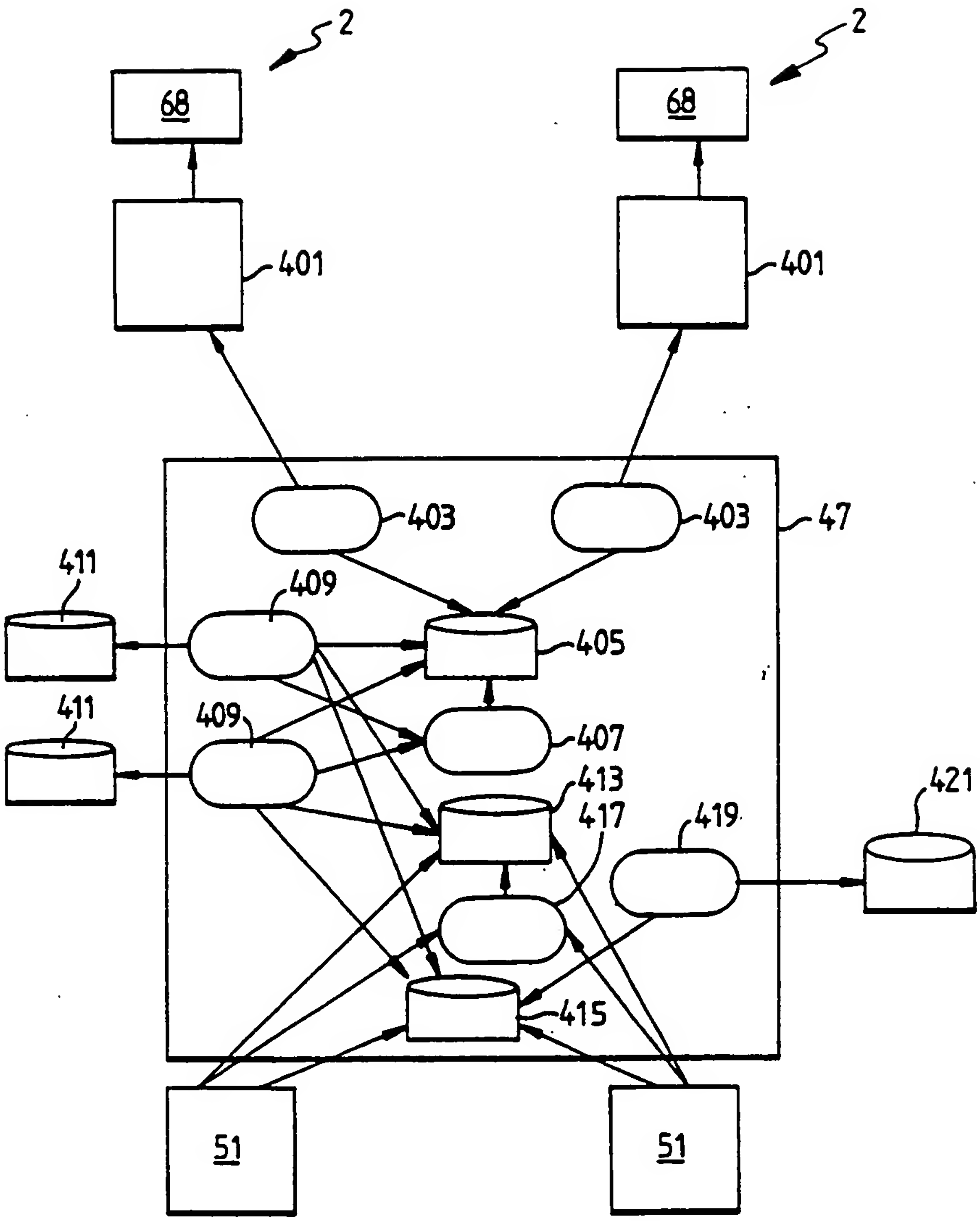

2
2
68
68
401
401
403
403
47
411
409
405
411
409
407
413
417
419
421
415
51
51

FIG 36

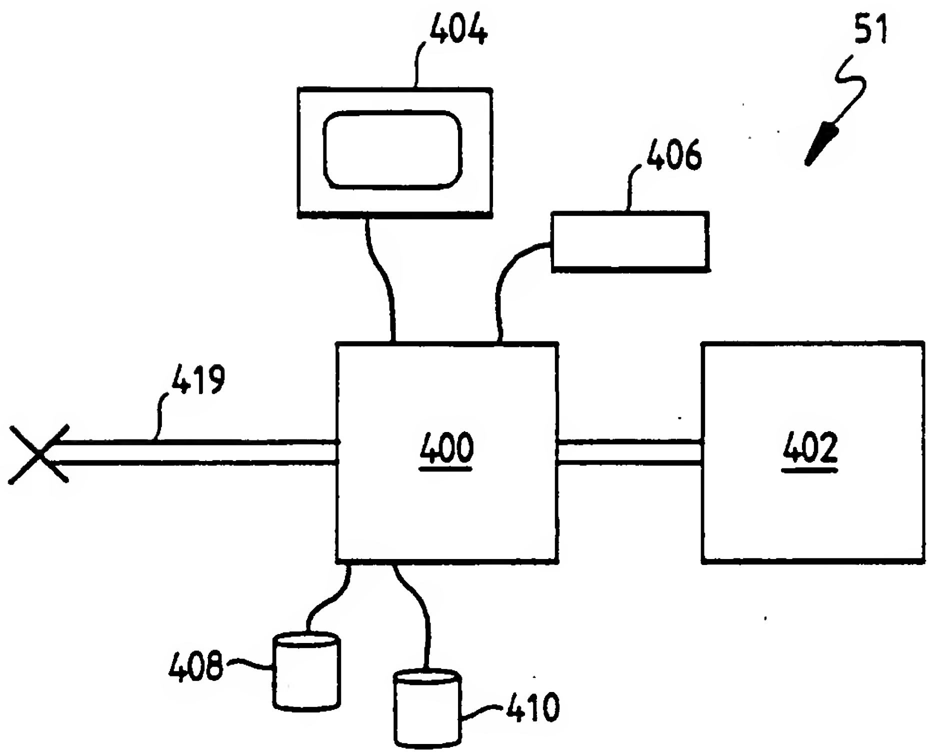


FIG 37

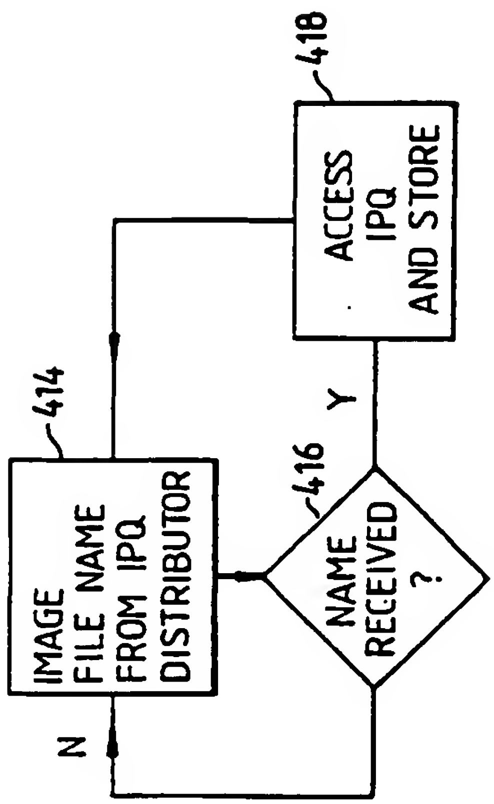


IMAGE FILE NAME FROM IPQ DISTRIBUTOR
414
NAME RECEIVED ?
416
N
Y
ACCESS IPQ AND STORE
418

FIG 38

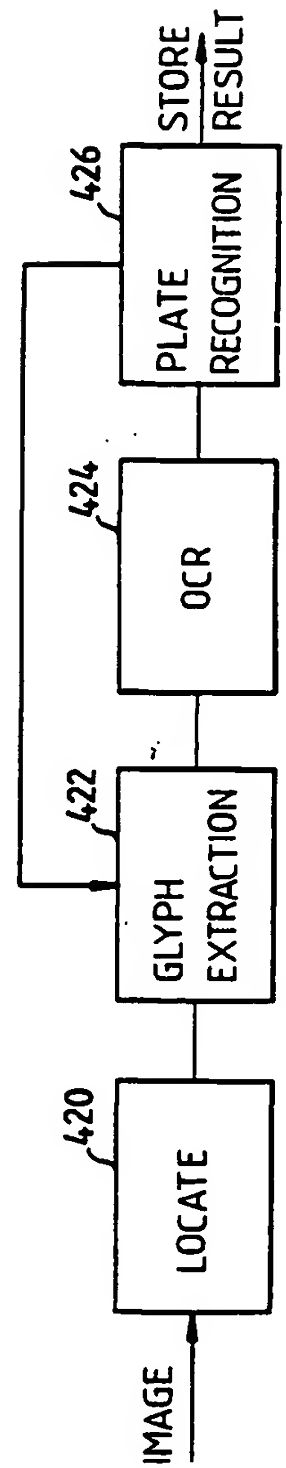


IMAGE
LOCATE
420
GLYPH EXTRACTION
422
OCR
424
PLATE RECOGNITION
426
STORE RESULT

FIG 39

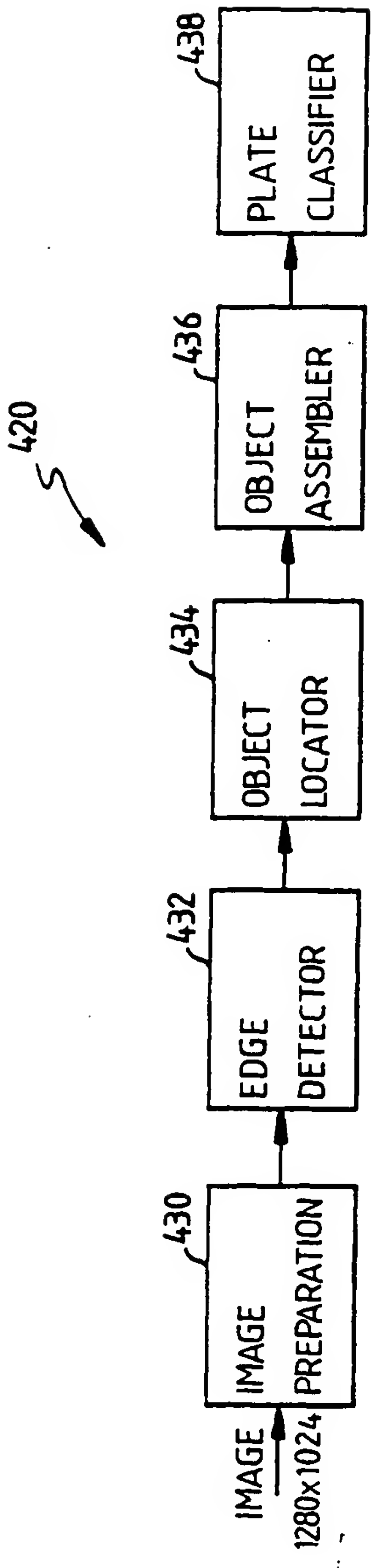

420
IMAGE
1280x1024
430
IMAGE
PREPARATION
432
EDGE
DETECTOR
434
OBJECT
LOCATOR
436
OBJECT
ASSEMBLER
438
PLATE
CLASSIFIER

FIG 40

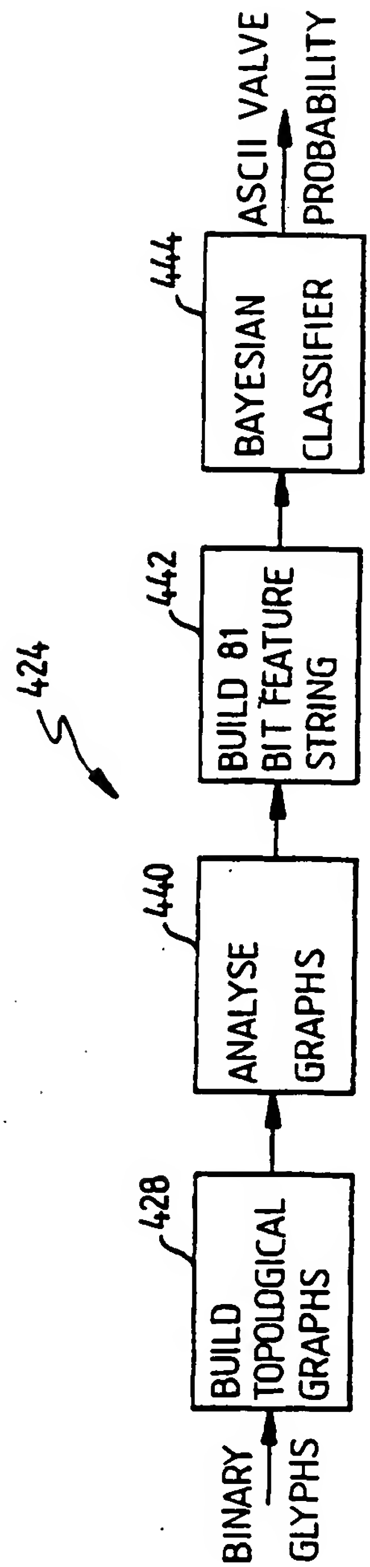

424
BINARY
GLYPHS
428
BUILD
TOPOLOGICAL
GRAPHS
440
ANALYSE
GRAPHS
442
BUILD 81
BIT FEATURE
STRING
444
BAYESIAN
CLASSIFIER
ASCII VALVE
PROBABILITY

FIG 41

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